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AROUSAL AND INFORMATION PROCESSING IN LEARNING DISABLED CHILDREN

by

© NOEL HENRY WILLIAMS

A THESIS
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DEDICATION

To my parents, whose early encouragement and sacrifice provided the basis for my academic career.

To my wife Margaret, who deserves much of the credit for the completion of this thesis. Her constant source of encouragement and assistance from the beginning of my undergraduate studies to the final reading of this thesis was a necessary condition for the completion of my graduate studies.

To my children, Lisa and Marc, who put up with an 'absent father' without too much complaining.

To the above, my deepest appreciation.

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ABSTRACT

Three studies are described in which different levels of arousal and information integration are examined in learning disabled children. Two arousal measures were used: (1) a behavioral measure which was a six-item Child Rating Scale, the items being hyperactivity, short attention span, variability, impulsivity, irritiability, and explosiveness; and (2) a physiological measure, the Galvanic Skin Response (GSR), with seven aspects of the GSR being measured, namely basal level, latency 1, latency 2, magnitude, recovery limb, spontaneous fluctuations, and habituation rate.

In the initial study, both measures were factor analyzed and one factor emerged on each analysis. Arousal was found to be unitary in nature on both measures. On the Child Rating Scale, all items loaded highly, with short attention span being the least sensitive index. On the GSR, spontaneous fluctuations and habituation rate were not included in the factor analysis, as they were not part of the response itself. All five other GSR components loaded highly, with basal level and recovery limb being the most salient features. Factor scores were obtained for each learning disabled child on each measure, and two distributions were drawn up, each of which was divided into three levels of arousal: high, medium and low.

The second study examined the relationship between the behaviorally aroused child and the physiologically aroused child, the result of which showed the presence of a negative relationship. Thus, the behaviorally

overaroused (hyperkinetic) child is physiologically underaroused. This condition is explained in terms of a lack of CNS inhibition.

The third study investigated the effect of different levels of arousal on information integration as measured by Das' tests of successive and simultaneous synthesis. The tests used were Raven's Progressive Matrices, Figure Copying, Digit span, Free recall, Serial recall, and Color naming. The learning disabled children as a whole were found to differ from the normal control group on Figure Copying and Free recall. When the learning disabled children were grouped into hyperkinetic and hypokinetic groups, the hyperkinetic children differed significantly from the normal control group on Free recall, Serial recall, and Figure Copying. The poor performance on the cognitive tasks by the hyperkinetic children is interpreted as an attentional deficit. To obtain a broader perspective on information processing, a comparison was made between the learning disabled children, a group of normal children, and a group of reading disabled children on cognitive data from previous studies. The results emphasized the heterogeneity that exists in a population of learning disabled children.

If an individual remedial program is to be effective, knowledge of: (1) arousal level and (2) specific cognitive difficulties in the child is essential.

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CHAPTER I

INTRODUCTION

The present study is concerned with exploring the possibility of diagnosing children with learning disabilities in terms of arousal levels, as measured by autonomic and behavioral activity. To date, no such diagnosis has been reported, but research workers in the field (Clausen, 1973; Johnson, 1963; Martin, 1973; O'Connor, 1973) suggest that it might be profitable to use arousal level as a measure of hyper- and hypokinetic behavior.

The theoretical frame of reference stems fundamentally from the studies of Luria (1961a, 1963). Luria's work has led him to conclude that children with learning problems differ in terms of excitation and inhibition of the nervous processes. Consequently, Luria suggests that three types of children experiencing learning difficulties can be identified. They are:

1. The excitable child where excitation predominates;
2. The inhibitory child where inhibition predominates;
3. The balanced child where there is an absence of a dominance of either excitation or inhibition but where both processes are weak.

This categorization of Luria corresponds to the terms 'hyperkinetic' and 'hypokinetic' that are used by researchers outside the Soviet Union. Thus, three groups of learning disabled children were involved in the present study: the hyperkinetic child (high arousal), the hypokinetic child (low arousal) and the normokinetic child (a child who is not hyper- or hypokinetic). Hyperkinesis implies not only excessive motor

activity but is also characterized by restlessness, distractibility and impulsiveness. Furthermore, a critical characteristic of hyperkinesis is that it is often situationally inappropriate. Thus, the teaching of learning disabled children is challenging, but learning disabled children that are also hyperkinetic pose even greater problems. Correct diagnosis of the hyperkinetic child is critical if remediation is to be effective. Current methods of diagnosing hyperkinesis are questionable. Two methods were examined: (a) a behavioral measured based on a child rating scale and (b) a physiological measure, the Galvanic Skin Response (GSR).

Another issue that is central to this study is that of information processing. Knowledge of how these three categories of children process information is necessary if remediation is to be effective. In the literature, one finds the suggestion that high and low levels of arousal may interfere with information processing (Keogh, 1972; Albiso, 1972). Strauss (Strauss & Lehtinen, 1947; Strauss & Kephart, 1955) also stressed a connection between arousal and information processing. Strauss ascribes difficulties in learning and deviant behavioral patterns to brain injury, but subsequent work has de-emphasized the etiological aspect of Strauss' work (Stevens & Birch, 1957), but has accepted the behavioral and cognitive characteristics associated with the 'Strauss Syndrome'. Luria (1966b) again provided the focus for investigation. Luria has developed a theory of information integration consisting of two types of synthesis, simultaneous and successive. In simultaneous synthesis, the child arranges the incoming stimuli in stimulus array, whereas successive synthesis requires the child to arrange the input in sequence.

Das (1972a, 1973) has developed a battery of tests which measure these processes, some of which are used in this study.

Luria (Luria, 1961b; Luria & Vinogradova, 1959) considers it important to "study the psychophysiological nature of abnormal traits and the physiological as well as the psychological mechanisms underlying the abnormal behavior (Luria, 1961b, p. 2)". This objective approach has not been used extensively in Western countries, but some researchers fully support it. Shipe (1969), for example, points out that some of the confusion in the concept of mental retardation and learning disabilities may be lessened by considering the conditions "in conjunction with our knowledge of the relation between neurophysiological processes and behavior, and of the cognitive processes (p. 114)". O'Connor (1973), in describing his own methodology in studying mental retardation, says that one must associate experimentally defined patterns of behavior with their neurological and physiological correlates such as found in experiments by Sylvester (1966), Blundell (1966), Berkson, Hermelin and O'Connor (1961), and O'Connor and Berkson (1963). Therefore, the relationship between arousal level and patterns of information integration need to be investigated. Prerequisites for this line of research are the development of objective indices of arousal and a proven measure of patterns of information processing.

In summary, the major objectives of the study were:

1. To explore the possibility of dividing learning disabled children on the basis of physiological arousal levels and behavioral ratings.
2. To ascertain the variables that best discriminate between different levels of arousal based on the GSR and the items in the child

rating scale.

3. To examine the relationship between physiological and behavioral methods of measuring arousal.
4. To investigate the effect that different levels of arousal might have on information integration.

CHAPTER II

REVIEW OF LITERATURE

In the present chapter, selective reviews will be found under three headings: the learning disabled child, arousal, and information processing.

A problem that exists in the area of learning disabilities is the diversity of behavior found in this population. This diversity has resulted in the development of numerous definitions, diagnostic procedures and remediation techniques, which have contributed to the confusion that surrounds the area of learning disabilities today. The review will highlight the important historical trends in learning disabilities and critically examine some of the diagnostic and remedial methods used today, culminating in a discussion of Luria's theory on which this study is based. The theory is expanded upon in the sections on arousal and information processing.

Historically, the study of arousal has had its roots in both physiology and psychology. The review will restrict itself to a brief discussion of the mechanism of arousal, consider the problems inherent in its measurement, and conclude with a discussion of the GSR as a good physiological index of arousal.

Understanding of how a learning disabled child processes information is important, if remediation is to be considered. This review concentrates on one such model of information processing that might aid that understanding.

The Learning Disabled Child

The term "learning disabilities' has become a catch-all term under which many labels and hypotheses have been thrown together. So diverse has been the application of the term that it has lost its initial function of conveying a clear and concise concept (Frierson & Barbe, 1967). This is not surprising when one considers the major disciplines which contribute to the study of learning disabilities (see Figure 1).

In 1964, a task force sponsored by the National Institute of Neurological Diseases and Blindness of the National Institute of Health and the National Society of Crippled Children and Adults in the USA was initiated to study the uses of terminology and identification. Clements (1966), the principal investigator, reported the following:

> A review of selected literature revealed a total of 38 terms to describe or distinguish the conditions grouped as minimal brain dysfunction in the absence of findings severe enough to warrant inclusion in an established category, e.g., cerebral palsies, mental subnormality, sensory defects (p. 9).

From this list it is evident that two avenues of approach exist towards understanding learning disabilities. The first approach is cause-orientated where terms are organically based, such as organic brain disease, minimal brain damage, cerebral dysfunction, and minimal cerebral palsy. The second approach concentrates on the behavioral consequences where the prime concern is analyzing, describing and modifying observed behaviors regardless of the underlying causes. Terms such as hyperkinetic syndrome, dyslexia, perceptually handicapped and clumsy child syndrome are used.

Perhaps the best way of understanding the present state of learning

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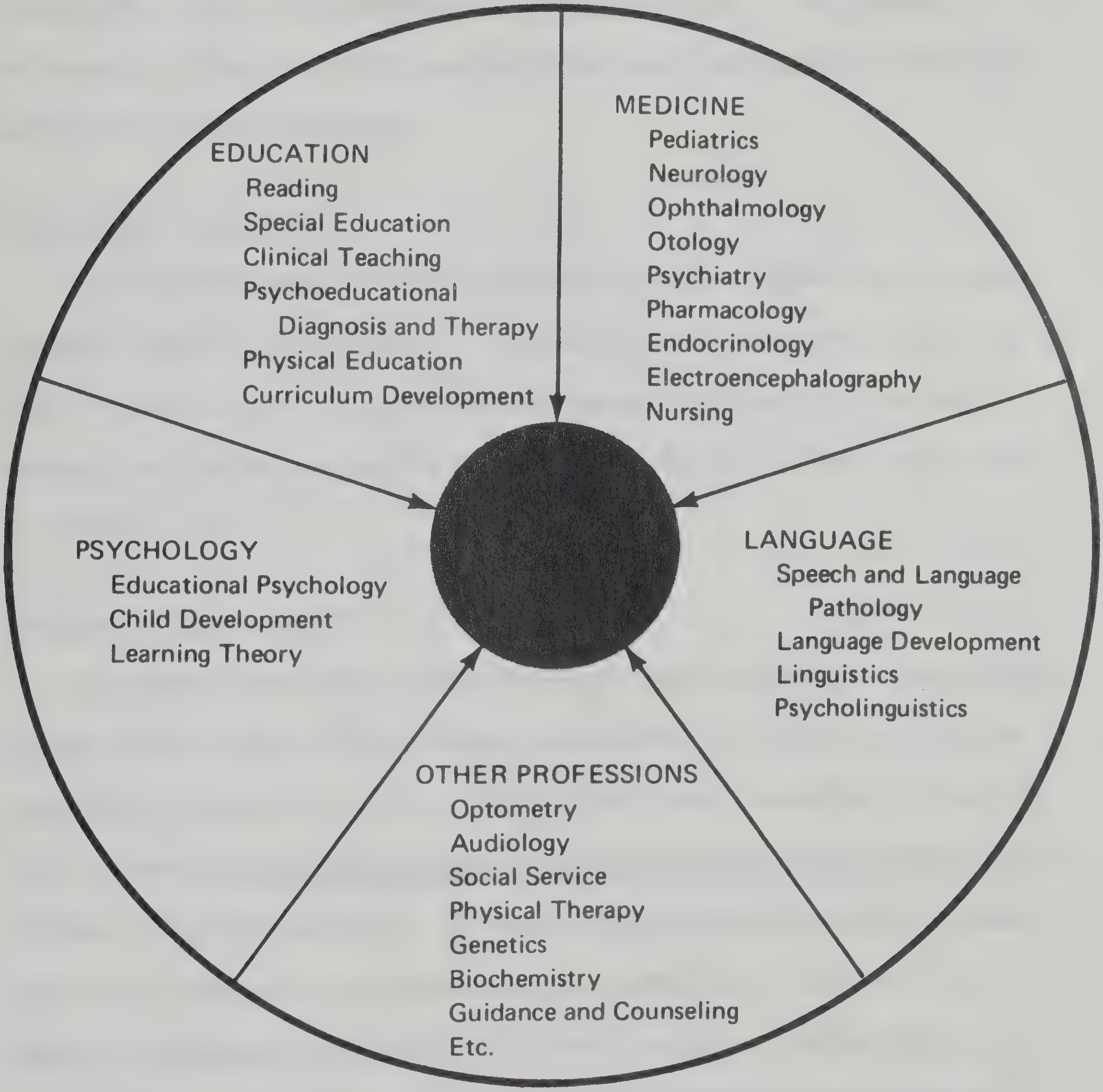


Fig. 1. Learning disabilities: An interdisciplinary field (after Lerner, 1971)

disabilities is to historically trace the forces responsible for fashioning this concept. However, the nature of this paper does not allow for a detailed historical analysis, but the main highlights as far as the writer is concerned, will be discussed. The reader is referred to Strother (1973) and Hallahan and Cruickshank (1973) for excellent historical reviews.

Historical highlights

The terminology of learning disabilities has been seen to pass through three distinct stages. Initially, children were classified as brain-injured, then as having minimal brain dysfunction, and most recently as having a specific learning disability. These stages are described below.

The brain-injured child

The pioneering work in the field of learning disabilities can be traced to the work of Heinz Werner and Alfred A. Strauss during the late 1930's and early 1940's. Their views were presented in the now-classic work *Psychopathology and education of the brain-injured child* (Strauss & Lehtinen, 1947). Strauss and Lehtinen witnessed a common behavioral pattern in children that were previously classified as mentally retarded, emotionally disturbed, autistic, behaviorally maladjusted, and aphasic. They therefore created a new category--brain-injured children.

Seeking a medical cause of the behavioral characteristics, Strauss suggested that the deviant learning and behavioral patterns of their children were manifestations of brain injury. From the results of his

studies, Strauss speculated that children with similar behavioral and learning characteristics to those of the children in his study had also experienced brain injury. Strauss concluded that brain injury could have taken place in the prenatal stage, during birth, or at some point after birth. The basic Strauss (Strauss & Lehtinen, 1947) definition is as follows:

> The brain-injured child is the child who before, during or after birth has received an injury to or suffered an infection of the brain. As a result of such organic impairment, defects of the neuromotor system may be present or absent; however, such a child may show disturbances in perception, thinking, and emotional behavior, either separately or in combination. This disturbance can be demonstrated by specific tests. These disturbances prevent or impede a normal learning process. Special educational methods have been devised to remedy these specific handicaps (p. 4).

Strauss theorized that the brain injury was exogenous as opposed to endogenous. Thus the impairment was due, not to a genetic pattern, but to an injury that occurred outside of the genetic structure. For example, brain injury resulting from anoxia or a fall on the head are exogenous causes.

Strauss described the brain-injured child as having seven characteristics, four behavioral and three biological in nature. The behavioral characteristics were:

1. Perceptual disorders: When viewing pictures these children would see parts instead of wholes and make figure-ground disturbances.
2. Perseveration: They continue on an activity once started and have great difficulty in changing sets.
3. Thinking or conceptual disorders: The child is unable to organize materials and thoughts in a normal way.

4. Behavioral disorders: Children display such characteristics as hyperactivity, explosiveness, erraticness or uninhibited behavior.

The biological characteristics were:

1. Slight neurological signs: This refers to subtle rather than obvious or severe evidence of neurological abnormalities. Awkwardness in gait is an example.
2. A history of neurological impairment: This refers to evidence in the medical history of brain injury that occurred before, during or after birth.
3. No history of mental retardation in the family.

The biological signs could be negative as far as Strauss was concerned and still be diagnosed as brain-injured on the basis of the behavioral characteristics.

Even though Strauss' work provided a meaningful and logical view of problem children, he was not without his critics. The terminology used by Strauss and his associates became confusing. Exogenous and endogenous causes became mixed up (Doll, 1951). Stevens and Birch (1957) summed up the criticisms and arrived at four main objections to the term brain injury:

1. The term is an etiological concept and does not appropriately describe the symptom complex. This is important because the condition which prevails is viewed in terms of symptoms rather than etiology.
2. The term is associated with other conditions,some of which have no relation to the symptom complex commonly referred to as 'brain injury'.
3. The term does not help in the development of a sound therapeutic approach and in practice teachers and clinicians tend to approach

the problem in terms of symptom reduction.

4. The term is not suited for use as a descriptive one since it is essentially a generic expression, the use of which results in oversimplification.

On the basis of the above criticisms, Stevens and Birch (1957) recommended the term 'Strauss Syndrome' to be used instead of brain-injured to describe the child who had difficulty in learning and did not fit into other classifications. Thus, the term 'Strauss Syndrome' was introduced to describe the child who exhibited several of the following characteristics (Stevens & Birch, 1957, p. 345):

1. Erratic and inappropriate behavior on mild provocation.
2. Increased motor activity disproportionate to the stimulus.
3. Poor organization of behavior.
4. Distractibility of more than ordinary degree under ordinary conditions.
5. Persistent faulty perceptions.
6. Persistent hyperactivity.
7. Awkwardness and consistently poor motor performance.

Minimal brain dysfunction

Research workers in the late 1950's and early 1960's observed that some children experienced learning difficulties that did not have the Strauss behavioral characteristics. Some children, for example, did not exhibit hyperactive behavior, were quiet and often withdrawn. Thus, during the 1960's, the term minimal brain dysfunction (MBD) became the label to include the Strauss-type child and other children with perceptual and learning problems. The shift in terminology resulted mainly from the work of Clements (1966) who defines MBD as follows:

> . . . children of near average, average or above average general intelligence with certain learning or behavioral disabilities ranging from mild to severe, which are

> associated with deviations of function of the central nervous system. These deviations may manifest themselves by various combinations of impairment in perception, conceptualization, language, memory, and control of attention, impulse, or motor function . . . these aberrations may arise from other illnesses or injuries sustained during the years which are critical for the development and maturation of the central nervous system, or from unknown causes (pp. 9-10).

This definition has much in common with the one of Strauss and Lehtinen (1947), but was more restrictive in that only children with near average or above average IQ were included. Strauss and Lehtinen did not impose such limitations. Furthermore, behavioral manifestations were expanded to include language and motor disorders. The term MBD differentiated the minimally involved child from the child with severe brain disorders. Table 1 illustrates this.

Clements' (1966) publication (known as Phase I) was the result of a task force study set up by the US Department of Health, Education and Welfare and the National Society for Crippled Children. Phase II and Phase III followed Clement's publication and were both published in 1969. Phase II was conducted by Haring (1969) and was mainly concerned with describing the educational and medical services available for the MBD child. Phase III (Chalfant & Scheffiin, 1969) focused upon the deviant behaviors that arise from dysfunction to the central processing mechanism, i.e., the analysis, storage, synthesis and symbolic use of information. Thus, the term Central Processing Dysfunction emerged.

Learning disabilities

Prior to the work of Clements (1966) a considerable number of professionals in the field of special education had begun to react to labels that had connotations of brain etiology. The criticism here is

Table 1

Classification Guide of Brain Dysfunction Syndromes
(Clements, 1966)

Minimal (minor, mild)	Major (severe)
1. Impairment of fine movement or co-ordination	1. Cerebral palsies
2. Electroencephalographic abnormalities without actual seizures, or possibly subclinical seizures which may be associated with fluctuations in behavior or intellectual function	2. Epilepsies
3. Deviations in attention, activity level, impulse control and affect	3. Autism and other gross disorders of mentation and behavior
4. Specific and circumscribed perceptual, intellectual and memory deficits	4. Mental subnormalities
5. Nonperipheral impairments of vision, hearing, haptics and speech	5. Blindness, deafness, and severe aphasia

that some children with the major brain injuries may or may not have difficulty in learning. For example, some children with cerebral palsy have no learning difficulty, whereas others exhibit mental retardation. Furthermore, some authorities in regard to the term MBD have asked the question, How much is minimal? It became increasingly clear that terms and definitions that had greater educational implications were required. Hence, Kirk (1962) coined the term 'learning disability' and defined it as follows:

> A learning disability refers to retardation, disorder or delayed development in one or more of the processes of speech, language, reading, spelling, writing or arithmetic resulting from a possible cerebral dysfunction and/or emotional or behavioral disturbance and not from mental retardation, sensory deprivation, or cultural or instructional factors (p. 263).

Like Clements (1966) the definition was broader than Strauss' definition of the brain-injured child, since it specified that the disabilities may exist as a disturbance in one or more processes. For the first time, one sees the notion of specific learning disabilities. However, the definitions of both Clements (1966) and Kirk (1962) do not include reference to the degree of severity of the learning disorder to qualify for inclusion. Thus, the learning disabled definition became a 'catch-all' term, whereby all children who had not been eligible under traditional handicapping conditions could be included.

Bateman (1965), a former student of Kirk, produced a definition that added a new dimension, that of the necessity to distinguish between capacity and achievement. It stated:

> Children who have learning disorders are those who manifest an educationally significant discrepancy between their estimated intellectual potential and actual level of

> performance related to basic disorders in the learning process, which may or may not be accompanied by demonstrable central nervous system dysfunction, and which are not secondary to generalized mental retardation, educational or cultural deprivation, severe emotional disturbance, or sensory loss (p. 220).

Because of the concern shown by special educators, the US Office of Education became involved in learning disabilities by providing financial funding for research, etc. In order for the Office to act accordingly, a definition was required. This was developed in 1968 and was included in a US Congressional Bill entitled "The Learning Disability Act of 1969". The definition states:

> Children with special (specific) learning disabilities exhibit a disorder in one or more of the basic psychological processes involved in understanding or in using spoken or written language. These may be manifested in disorders of listening, thinking, talking, reading, writing, spelling or arithmetic. They include conditions which have been referred to as perceptual handicaps, brain injury, minimal brain dysfunction, dyslexia, developmental aphasia, etc. They do not include learning problems which are due primarily to visual, hearing or motor handicaps, to mental retardation, to emotional disturbance, or to environmental disadvantage (p. 14).

Dunn (1973) and Haring (1974) have both criticized this definition as not being directly applicable to the classroom situation but helpful to the administrator because of its legalistic overtones.

Wiederholt (1974) suggests that parents and professionals have been calling for an operational definition, which clearly identifies the learning disabled population. In response to this, Chalfant and King (1976) maintain that many existing definitions can be made operational, and propose a method "for operationalizing disabilities in order to identify precisely the population in question". Chalfant and King (1976)

examined nine widely used definitions and found that they all focused on five components: task failure, exclusion factors, physiological correlates, discrepancy, and psychological correlates. They recommend that, in identifying learning disabled children, all five definitional components must be applied to the child. Operationalizing the first four components presents no great problem, but to operationalize the psychological correlates is more difficult. In discussing psychological correlates, Chalfant and King (1976) use an information processing model involving three major dimensions which are important to learning: (1) the sensory input system; (2) the output or response system; and (3) the psychological processes. While the first two dimensions can be observed and measured, the psychological processes are not directly observable, but inferences can be made from the observed behavior. Five processes are identified: attention, discrimination, memory, concept formation and problem solving; and while few standardized tests are available for quantifying process dysfunction, it is possible to describe the key behavioral indicators of each dysfunction. They suggest that all five components are important in the definition, and that the answer to many of the problems in learning disabled children lies in understanding the psychological processes. Chalfant and King (1976) are not alone in their belief, for Wepman, Cruickshank, Deutsch, Morency and Strother (1975) and Ross (1976) include, in their respective definitions of learning disabilities, specific processing dysfunction.

The definition of Wepman _et al_. (1975) grew out of their participation in the National Project on the Classification of Exceptional Children under the guidance of Nicholas Hobbs (1975). Wepman _et al_. (1975)

feel that the term learning disability is too general, having no consistent meaning and no value for a basis on which a remedial program can be developed. They strongly advise that "efforts must be directed toward more precise and objective definitions of relatively homogeneous subgroups (Wepman et al., 1975)". Thus their definition emphasizes that a child with a specific learning disability has a perceptual dysfunction. The definition they propose is as follows:

> Specific learning disability, as defined here, refers to those children of any age who demonstrate a substantial deficiency in a particular aspect of academic achievement because of perceptual or perceptual-motor handicaps, regardless of etiology or other contributing factors. The term perceptual as used here relates to those mental (neurological) processes through which the child acquires his basic alphabets of sounds and forms (Wepman et al., 1975, p. 306).

Ross (1976) takes a similar point of view and argues for a narrowing of the learning disability definition to accommodate the different subgroups that exist in a learning disabled population. He argues that a definition derived by exclusion is not the answer. If those clauses, which specify what a learning disability is not, are removed, the definition becomes circular, merely stating that a learning disability is an inability to learn. Such a definition is too broad and needs refinement. An examination of the literature in learning disabilities led Ross (1976) to conclude that a large group of learning disabled children have difficulty in their ability to sustain selective attention. Ross' definition reads as follows:

> A learning disability is present when a child does not manifest general mental subnormality, does not show an impairment of visual or auditory functions, is not prevented from pursuing educational tasks by unrelated psychological disorders, and is provided with adequate

> cultural and educational advantages but nonetheless manifests an impairment in academic achievement that is associated with difficulties in sustaining selective attention (Ross, 1976, p. 11).

Ross (1976) points out that his definition reduces the learning disabled group to a more homogeneous one, but hastens to add that there are other children who fail in academic subjects where the problem "has its basis in some other phase of the information-processing function we call learning (Ross, 1976)".

Needless to say, the development of a definition is problematic and it is difficult, if not impossible, for one to compose an inclusive and universally accepted definition of learning disabilities. However, there appears to be a trend in recent years for the narrowing down of the definition by referring directly to the specific processing dysfunction in the child. Such a trend has the needed function of identifying homogeneous subgroups, whereby a clearer picture of the child's problem will emerge.

Characteristics

If one considers the learning disability definition, there are actually only three characteristics that all learning disability children have in common:

1. They must have a near average, average or above average intelligence.
2. They must have sensory acuity.
3. They must be achieving academically considerably less than their peers of same IQ, age and educational opportunity.

However, a great number of other characteristics are found in addition to the above three. These characteristics may be divided

arbitrarily into at least six categories, including: (1) motor activity, (2) emotionality, (3) perception, (4) symbolization, (5) attention, and (6) memory. The ten most frequently reported behavior and learning difficulties in brain-injured children were listed by Clements (1966) in the following order:

1. Hyperactivity and restlessness.
2. Perceptual motor impairments, such as poor drawing and constructional skills.
3. Emotional lability, such as sudden emotional outbursts without obvious cause.
4. General orientation defects, such as clumsiness and poor motor co-ordination.
5. Attention disorders, such as distractibility and perseveration.
6. Impulsivity.
7. Disorders of memory and thinking.
8. Specific learning disabilities in reading, arithmetic, writing, and spelling.
9. Speech and hearing disorders.
10. Equivocal neurological signs and electroencephalographic irregularities.

Generally speaking, combinations of these characteristics are found in the child experiencing learning difficulties and it is these combinations that contribute to the real problems of the child and to the diagnosis of learning problems. Furthermore, the same characteristics are often found together, revealing identifiable symptom clusters, which result in the appearance of definitions and terms once again. For example, hyperkinesis refers to a symptom constellation of hyperactivity, impulsiveness, short attention span, emotional lability, and learning difficulties.

Werry (1968) indicates the need to define with more precision the nature of basic handicaps in learning disabled children, to improve diagnosis and remediation. Furthermore, Werry suggests that whatever term be used, it should be descriptive to help in educational aspects

and not medically oriented which often reflects etiology. Conners (1967) concurs with this view by saying that any terminology should be "descriptive and prescriptive for action", not a statement of etiology. Werry (1968) further suggests that more emphasis should be placed on empirical and statistical techniques, such as factor analysis, to help delineate and clarify behaviors that are symptomatic of children who have motor activity problems.

It is quite obvious that learning disabilities are characterized by definitions and labeling that have developed to suit the research and funding needs, convenience or fancies of individuals. Strictly speaking, learning disabilities should be described in terms of the difficulty experienced in school-related subjects. Thus, a child experiencing difficulty in arithmetic or reading can be truly called learning disabled. However, the label MBD or brain injury suggests that learning disabilities are a symptom of brain damage and it would seem that both are related. The symptoms of one cannot be separated from the manifestations of the other, and for all practical reasons, it is probably best to consider the MBD child as equal to the learning disabled child (Das, 1973).

To conclude this section, a case study will be presented to provide a picture of one of the many kinds of children found under the term learning disabled. The case study is taken from Bowley and Gardner (1972):

> GRAHAM: referred to the Schools Psychological Service for 'backwardness and emotional disturbance' at age 7. Psychological interview showed normal general intelligence (Binet IQ approximately 100) but with many odd and uneven features. Graham was noted to be particularly poor at copying and creating drawings: on purely practical tests of his performance abilities, severe visual motor and visual perceptual difficulties were shown (Wechsler Performance IQ approximately 60 compared to a Verbal IQ of over 100).
>
> His educational attainments were also uneven: his reading was almost normal whilst his writing and arithmetic

> were practically nil. He could count a little by rote but had no knowledge of number concepts.
>
> His major problems were in his behavior: his distractibility and restlessness were extreme. In the individual interview he showed considerable 'forced responsiveness', was easily distracted by slight visual and auditory cues, and quite unable to stick to the point in conversation. Linked with this was his excessive motor disinhibition--he seemed compelled to touch things and could rarely sit and contemplate anything. He also showed occasional perseveration, repeating questions, drawings, and odd movements, such as obsessionally patting his head. His speech was telegraphic.
>
> His general behavior was even worse. He was generally hyperactive, restless and unconforming in the classroom, wandering around, failing to join in group activities, lying on the floor when he felt inclined or under the teacher's desk, showing many odd movements, talking to himself. He was such an interference with the work and behavior of other children that he was offered only part-time infant schooling after the age of 5 1/2 and excluded completely from school at the age of 7. The school noted his vivid imagination, but apart from his keenness on animals, they could find nothing positive to say about him and tended to regard him as subnormal.
>
> The medical history was suggestive but not very definite. He had been disagnosed at the age of 3 as a case of mild hypotonia and clumsiness. His EEG showed nothing strongly abnormal. His early history showed some difficulties at birth. His mother was unwell throughout the pregnancy with a threatened abortion, and he was jaundiced on the second day and seemed sleepy and did not suck well for some time. Developmental milestones were rather slow; he walked at 17 months but fell easily. He was treated for 'knock knees'.
>
> His family is of professional class and there are two younger normal siblings. His mother was a very sensible, warm person and was becoming very despondent about Graham's behavior both at home and at school. The parents were at a loss to account for his behavior and at odds with the school authorities (pp. 54-55).

Diagnosis and remediation

IQ and diagnostic tests. Children with obvious handicaps, the blind, the deaf, etc., are identified before entering school. Children with learning problems, however, are usually identified at first by the school teacher. Thus, the role of the psychologist is seen as

differential diagnosis and the provision of remedial strategies to combat the learning problems. More often than not, the psychologist's report merely contains the original diagnosis of the teacher and no insight is provided concerning the child's problem. Why is this? Several reasons account for this situation.

1. Standardized instruments. It has been shown that standardized IQ and diagnostic tests have certain limitations.

(a) Results are usually expressed in a single unitary score, as for example IQ. This sort of score quantifies something, suggesting that the child has 'too little of', 'enough of', or 'a great deal of' whatever is being measured (Keogh, 1972). Take the ITPA, for example, which presumably looks at functional processes, measures amounts or quantity as defined by particular subtests. Children are often described as having 'a deficit in auditory sequencing' or as 'normal in visual memory', etc. This type of quantification does not provide direction in solving the problem.

(b) The test response of a child indicates what a child can do, but does not indicate the underlying processes of the response (Sigel, 1963). In fact, the test provides limited information about how the solution was obtained or in cases of failure, the reasons why. Sigel (1963) points out that "a correct answer to an analogies item, for example, may be a function of particular learning, perceptual discrimination, syllogistic reasoning or any combination of these (p. 40)". These same points are echoed by McNemar (1964) who says that psychometric studies of individual differences in intelligence test performance have "never come to grips with the process, or

operation, by which a given organism achieves an intellectual response (p. 881)". Biggs (1968, 1969) indicates that while the IQ score provides a useful measure of general intelligence, it does not identify specific skills or qualitative differences in coding information. This score is merely a quantitative measure giving no clue as to why differences exist in these measures, and therefore does not consider individual variation in cognitive strategies found in children.

(c) Quite often test manuals fail to consider as being correct responses those which deviate from the prescribed. Thus children are penalized for nonconventional, original or novel responses.

2. Inability to differentiate groups. One would think that, with psychological testing, the mentally retarded and learning disabled would, based on their definitions, be easily identified. Unfortunately, this is not the case. Psychological tests, while capable of differentiating mentally retarded and learning disabled from the 'normal' population, have little success in differentiating these clinical groups from each other, and have even less success in diagnosing individual cases (Haywood, 1967). Dunn (1968) discusses a study involving several clinical teams who were unable to agree on the percentage of patients who could be diagnosed as mentally retarded, learning disabled and emotionally disturbed. He concluded that the diagnostic category selected by the clinicians depended on their previous training and biases.

The learning disabled child is often placed into the 'Strauss Syndrome', which suggests four behavioral characteristics as symptomatic, namely perceptual disorders, perseveration, thinking and conceptual

disorders and behavioral disorders (hyperactivity and disinhibition). These characteristics are also diagnostic variables in mental retardation. This confusion has led Haywood (1967) to conclude that no adequate set of criteria exists for diagnosing the learning disabled child so as to positively differentiate him from the mentally retarded. Other research workers have also expressed this feeling (Sabatino & Hayden, 1970; Palkes & Stewart, 1972; Benton, 1973).

3. Task and situational variables. Usually if a child does poorly on psychological tests, the failure is attributed directly to the child, and not to the task and immediate environment in which the child is placed when taking the test. Adelman (1971) points out that one must look at the task and environment and has proposed a three level model to define learning problems. Thus, only one-third and the smallest category of children are viewed as having a definite deficit, that will do 'poorly' no matter what situation they are in. The two other groups with learning problems are a result of match or mismatch between situation and child which produces success or failure in learning. Feshbach and Adelman (1971) point out that a change in situation, e.g., a different teacher, or a different instruction strategy, or more powerful reinforcers will bring about a change. Friebergs and Douglas (1969) support this concept, for they showed that hyperactive, distractible children with severe learning problems learned as well as normals when reinforcement schedules were changed. However, Keogh (1972) has pointed out that standardized tests given under the same conditions and with the same reinforcers form the basis of the major recommendations concerning placement and remediation.

The use of present day IQ and diagnostic tests have been questioned. From the above studies, it is seen that test results are the interactional end products of examiner, examinee and situational variables. It is not surprising, therefore, that the revaluation of tests has been called for. Suggested ways of accomplishing this are as follows:

(a) Traditional test batteries need to be expanded to include test items to get at process variables or modes of functioning. Hunt, Frost and Lunneborg (1973) have indicated that "intellectual assessment is all too often descriptive rather than prescriptive". They state that it is time, therefore, for a change whereby individual tests of intelligence should also measure details of cognitive strategies that may well be applied by the individual in problem solving. Keogh (1972), commenting on such changes, says: "On the assumption that qualitative as well as quantitative characteristics of performance are important in comprehensive diagnosis, the school psychologist needs to give up the security of his standardized test bag and look at how children approach and solve problems (p. 144)".

(b) A shift in emphasis from the search for deficiencies to one of strengths. Identification of the child's strengths which relate to the tasks to be learned provides a sound basis for remediation which can be easily implemented by the teacher.

Remedial programs. The remedial programs for children with learning problems have involved a great deal of work on behalf of their originators. Among the most prominent are Strauss (Strauss & Lehtinen, 1947; Strauss & Kephart, 1955), Cruickshank (1961), Kephart (1960, 1972), Kirk (1968), and Frostig (1961). Research has shown (Bibacc & Hancock,

1970; Mann, 1971; Hammill & Wiederholt, 1973) that the efficacy of their programs are in doubt. The general complaint is that the tests given to detect basic deficiencies in learning disabled children do not have a sound practical validity and in some cases do not have a sound theoretical basis, with the result that test behavior has been seen to improve but academic achievement has not. A detailed analysis can be found in Hallahan and Cruickshank (1973) of most of these programs, therefore only a few illustrative examples will be discussed.

1. The Frostig test. The Frostig test, called the Developmental Test of Visual Perception (DTVP) (Frostig, Lefer & Whittlesey, 1961) was standardized on a sample of 2,116 nursery and public school children between the ages of 3 and 9. They were white, middle class American children from Southern California. However, one sees that the test is constantly being used on a population that differs from the standardized population, e.g., learning disabled children (Lewis, 1968), mentally retarded (Allen, Dickman & Haupt, 1966; Alley, 1968), cerebral palsy (Tyson, 1963), economically deprived (Wiederholt & Hammill, 1971). Except for economically deprived, no studies have been carried out to demonstrate that the test is in fact reliable or valid when used with exceptional children. Based on the Frostig test, the Frostig-Horne Program of Visual Perception (Frostig & Horne, 1964) was developed for remediation purposes. In discussing its efficacy, Hammill and Wiederholt (1973) surveyed 35 perceptual intervention studies, of which 23 used the Frostig-Horne program. The major findings indicated that the Frostig training program in perception has no effect on reading and is questionable in terms of its effect on school readiness and perception itself.

2. The Illinois Test of Psycholinguistic Abilities. The Illinois Test of Psycholinguistic Abilities (ITPA) by McCarthy and Kirk (1961) and Kirk, McCarthy and Kirk (1968) has also been extensively investigated concerning its reliability and validity and related remedial program. An extensive review of the research by Sedlack and Wiener (1973) points out that the ITPA has not shown consistent effectiveness as a basis for differential diagnosis and remediation:

> The ITPA substantially predicts school achievement and distinguishes between cultural, ethnic and intellectual groupings; but remediation programs based on the ITPA have not shown significant achievement, related gains or long term changes in performance on the ITPA (p. 148).

Thus, tests administered to children should include techniques designed to allow for differences in information processing. Also, in diagnosing children with learning problems, emphasis should be placed on behavioral differences and not on IQ measures. In terms of behavioral differences, research workers of late have suggested that arousal be a main concern of investigation (Clausen, 1973; O'Connor, 1973; Hermelin & O'Connor, 1970).

In view of these criticisms, then, there is a need for a sound theoretical base on which: (1) the interpretation of the behavior of the learning disabled child, and (2) the subsequent development of a remedial program be placed. Such a theory cannot be derived from psychometric testing, since most tests used to diagnose learning disabilities do not have either a sound theoretical base or practical validity. One such theory that might provide the required base is that of Luria (1973) where arousal and information processing are prime concerns.

Luria's theory

The approach to be taken is based on the theoretical and methodological writings of the Russian psychologist A. R. Luria. What follows is a very brief outline of his theory which will be expanded upon in the sections on arousal and information processing.

Essentially, Luria (1965, 1966a, 1966b, 1970, 1971, 1973) considers the brain to consist of "three principal functional units" or blocks (see Figure 2), the participation of which is essential for any type of mental activity.

Unit 1 is concerned with regulating the tone and maintaining the waking state of the cortex, a function that is necessary for optimal cortical activity. This unit includes the upper and lower brain stem, reticular formation and hippocampus. Any damage to this unit will produce marked changes in behavior such as disturbances in arousal levels.

Unit 2 is involved in obtaining, processing and storing of information, which is situated in the lateral regions of the neocortex, "on the convex surface of the hemisphere (Luria, 1973, p. 67)", which includes the occipital, temporal and parietal lobes. In this unit a hierarchical arrangement of cortical areas exists: the primary or projection zones, the function of which is to receive information and analyze it into "elementary components"; the secondary or projective-association zones where the elements are organized and further coded; and the tertiary zone where information from various sources overlap and are organized to form the basis of complex behavior.

Unit 3 is responsible for the planning and programming of behavior, which is located in the frontal lobes. Luria elaborates:

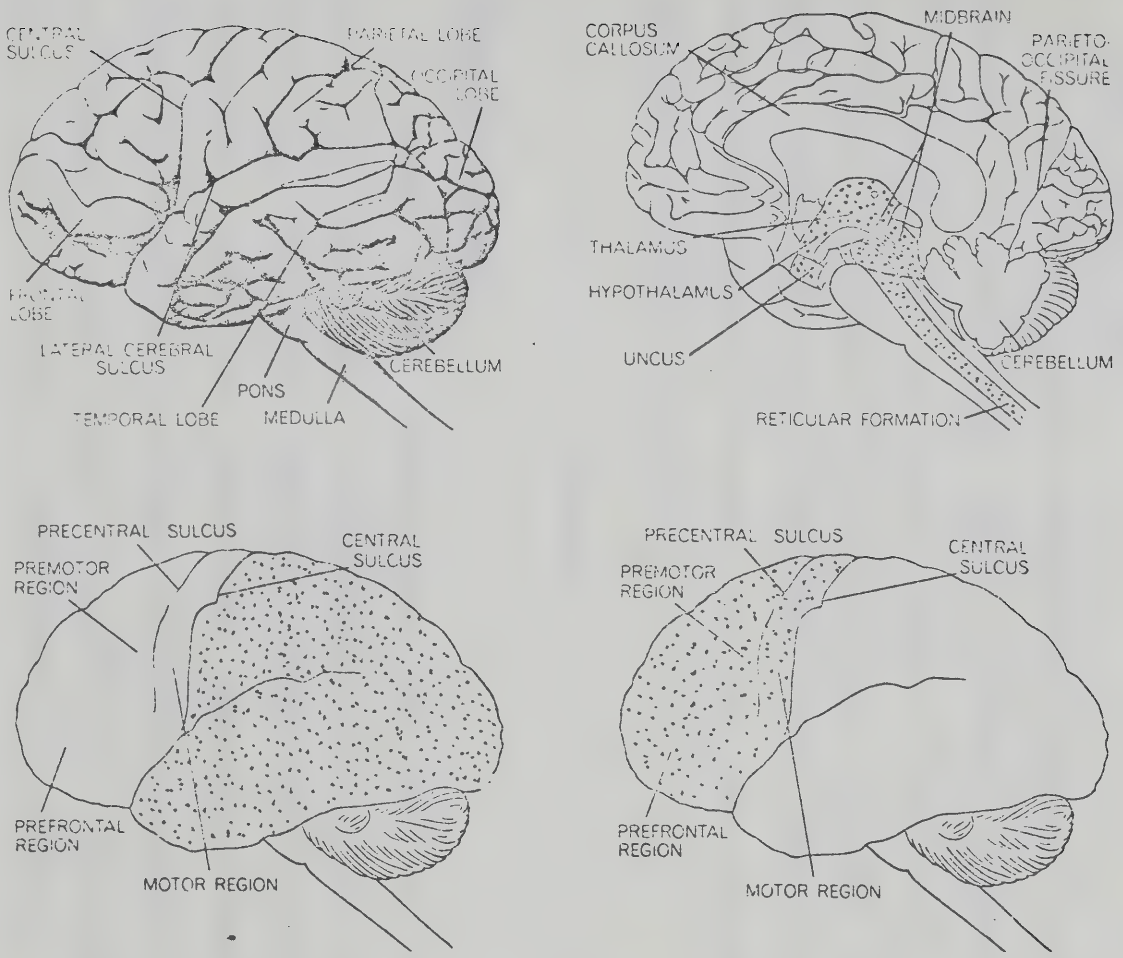


Fig. 2. Major blocks of the brain: gross anatomy (upper left); first block (upper right) for regulating energy level of cortex and responding to stimuli; the second block (lower left) for analysis, coding and storage of information; the third block (lower right) for formation of intentions and programs (after Luria, 1970)

> Man not only reacts passively to incoming information, but creates intentions, forms plans and programs of his actions, inspects their performance, and regulates his behavior so that it conforms to these plans and programs; finally, he verifies his conscious activity, comparing the effects of his actions with the original intentions and correcting any mistakes he has made (Luria, 1973, p. 80).

The units do not function separately but constantly interact with one another. For example, this study is concerned with arousal, and as indicated above, the reticular formation found in Unit 1 is responsible for regulating and maintaining the waking state of the cortex. However, the frontal lobes of Unit 3 have a powerful modulating influence on the reticular formation. Thus, they also contribute to the regulation of the state of activity.

Arousal

The nature of arousal

The concept of arousal appears to have two origins, one psychological and the other physiological. In psychological theory it can probably be traced to the work of Cannon (1915) who used the notion of 'energy mobilization'. Duffy (1934) used the term 'degree of excitement', defining this concept as "the extent to which the organism as a whole is activated or aroused". The term 'activation' soon replaced other terms. It was put forward by Lindsley (1951) and, according to Schlosberg (1954), was a better term since it encompasses an increase in both activity and reactivity. Schlosberg also pointed out the existence of a curvilinear relationship between activation and behavioral efficiency which manifests itself in the form of an inverted

U function. The inverted U function was elaborated upon by Hebb (1955) and Malmo (1959). Hebb (1955) distinguished two variables which control a response as optimally performed or not. The first variable, 'cue function', relates to the properties of the stimulus that is responsible to the elicitation of a response. The other variable, arousal, determines whether and how effectively the response is performed (see Figure 3). The stimulus would become more effective from low to medium arousal, and less effective in a high state of arousal. This relationship is recognized by Hebb as a reformulation of the Yerkes-Dodson law relating drive strength and performance.

In 1949, however, Moruzzi and Magoun discovered a special nervous structure in the brain stem which is specially adapted both by its anatomical and functional properties to be the principal mechanism in regulating the state of the cerebral cortex, having the power to change its tone and maintain its waking state. The close relationship with the earlier ideas, and the physiological concept of arousal arising from the work on the reticular formation, have led to the earlier psychological constructs being incorporated under the term arousal (Hebb, 1955; Malmo, 1959). Thus, in contemporary psychology, the concept of arousal is used to describe several psychological processes, but is considered basically a physiological process. French (1960) states:

> It now appears likely that the brain-stem reticular formation represents one of the more important integrating structures if not, indeed, the master control mechanism in the central nervous system . . . First, it is known to be implicated in the arousal response and wakefulness. Second, it exerts a critical degree of influence over motor functions concerned in phasic and tonic muscular

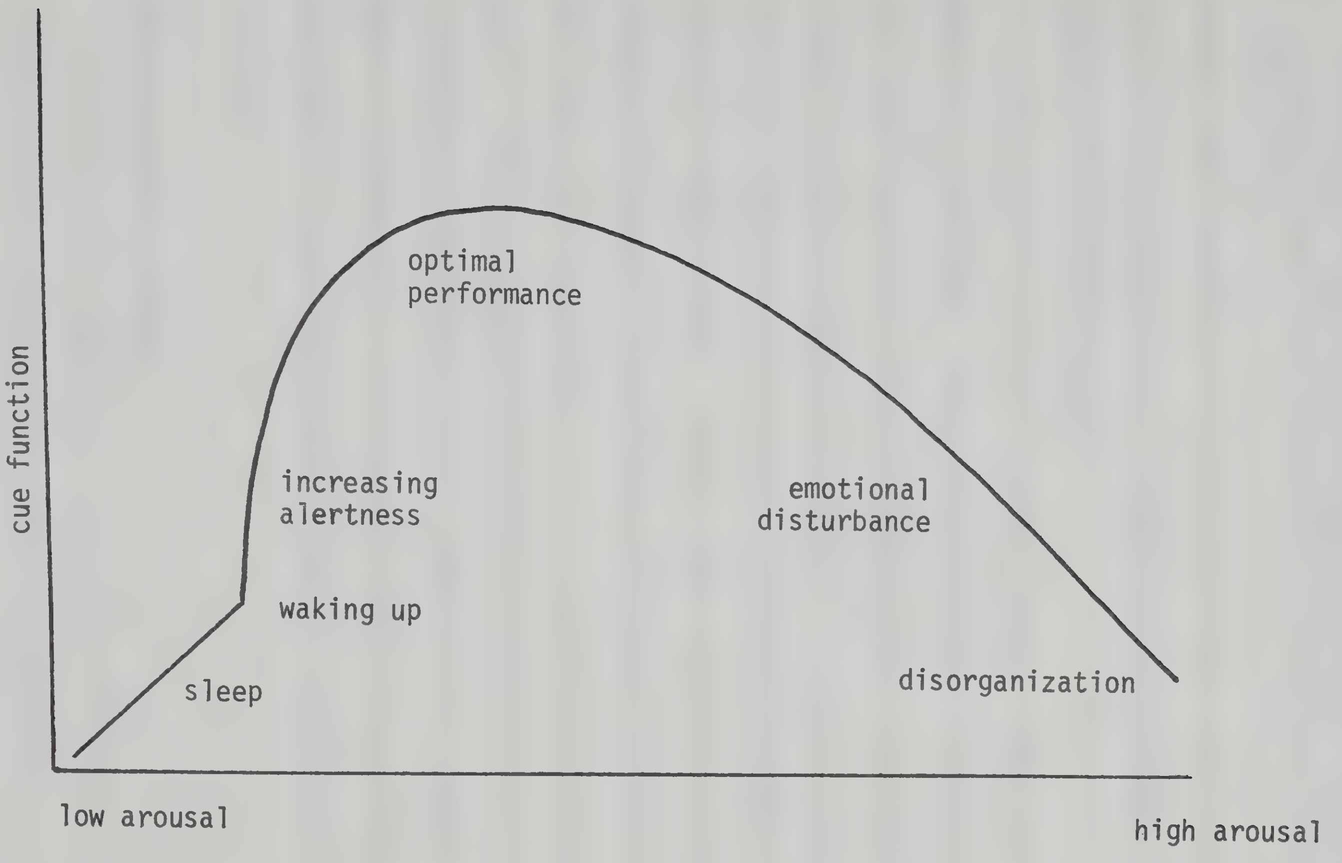


Fig. 3. Relation of the effectiveness with which stimuli guide behavior (cue function) to the level of arousal (after Hebb, 1966)

> control. Third, the central brain stem is capable of modifying the reception, conduction and integration of all sensory signals to the degree that some will be perceived and others rejected by the nervous system (p. 1281).

Berlyne (1960) agrees with French when he says that the ascending reticular activating system is responsible for keeping the individual receptive to incoming stimuli.

Psychologists who have discussed arousal theory have usually stopped short of a definition. There are many reasons for this, one of them being that appropriate indices and techniques to measure states of arousal have been established gradually. Also, the degree and direction of arousal shown by any individual at any given moment in time is a function of many factors. These include external and internal stimulation as well as "the degree of arousal of the nervous system which can exist independently of any sensory input (Hermelin & O'Connor, 1970)". For the purpose of this study, Clausen's (1973) definition will be used which states that arousal "refers to the general response or response readiness of an individual, modifiable by stimulation and measurable in terms of performance level or psychophysiological activity (p. 286).

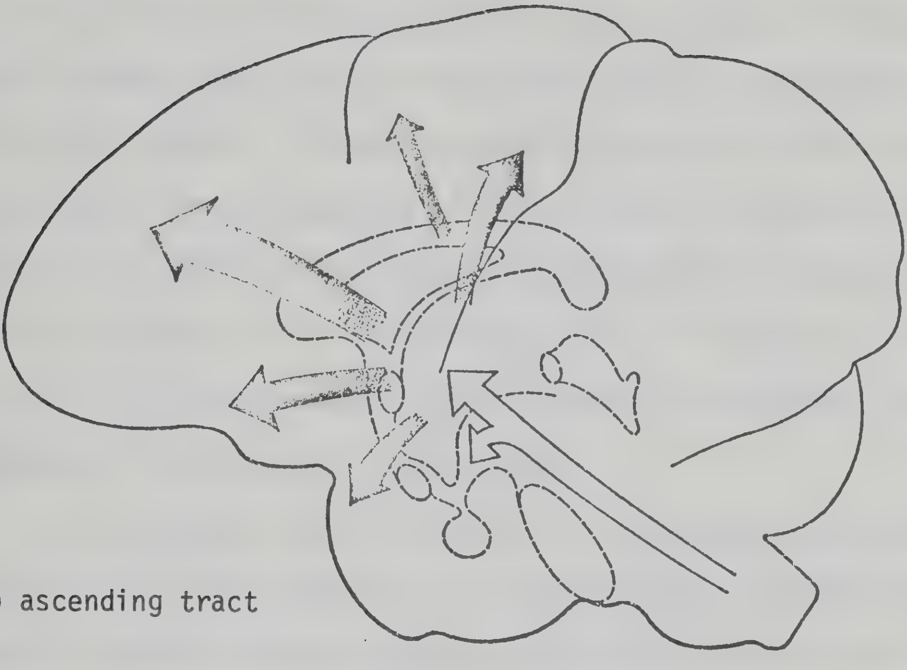
The mechanism of arousal

The reticular formation is situated in the brain stem. It extends all the way from the rear of the medulla oblongata up to the mid-brain and even into part of the forebrain known as the hypothalamus (see Figure 2). It is called reticular since microscopic examination has shown that it consists of a diffuse aggregation of cells of different

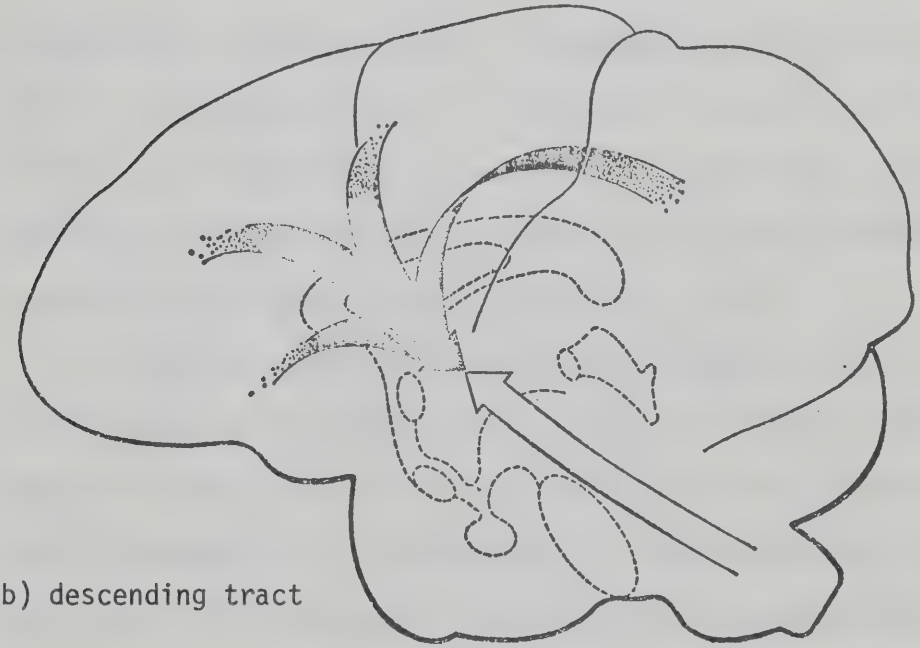
types and sizes, separated by a wealth of fibres running in all regions.

Because the normal activation of the brain depends on the reticular formation, it is called the reticular activating system (RAS). This system has been divided into two systems, depending on which way the fibres run (see Figure 4). There is the ascending reticular activating system (ARAS), where the fibres run upwards and terminate in the neocortical regions. The ARAS plays a major role in activating the cortex and regulating the state of its activity. On the other hand, there is the descending reticular activating system (DRAS), whose fibres run in the opposite direction from the neocortical regions to the lower structures of the brain stem. The function of the DRAS is to program the lower structures of the brain stem to control the cortical activity, to ensure that the waking state is at its optimal level for good performance.

Research evidence concerning the functions of the reticular formation is plentiful. Evidence concerning regulating the tone of the cortex and modulating its state is seen in the work done on animals by French (1960), Hernandez-Peon (1969), Jasper (1958, 1963), Lindsley (1960, 1961), Magoun (1963), Pribram (1960, 1967, 1971), to mention a few. These studies have used one of two techniques: (1) electrical stimulation or (2) lesions--the destruction or removal of brain tissue. Electrical stimulation of the brain is a useful technique since the brain not only generates electrical signals which may be recorded but is also responsive to electrical stimulation. This procedure involves the implantation of an electrode into the brain through which an electric current is passed. The animal responds in a particular manner, depending on the site of



(a) ascending tract



(b) descending tract

Fig. 4. Diagram showing relations of cortical systems with brain-stem structures through the ascending reticular formation (after Magoun)

stimulation and the behavior may range from a simple muscle twitch to a series of complicated movements as seen in states of fear and arousal. The procedures involved in brain lesion studies on the other hand are relatively simple. Following damage to the brain tissue, changes in the behavior of the organism or in the remaining portions of the brain tissue are measured. One such lesion technique is ablation, the removal of a particular part of the nervous tissue. An adjunct to this method is the study of behavioral changes in humans whose brains have been damaged or are diseased (Teuber, 1960).

It is apparent from the results of the studies mentioned above that stimulation of the rostral part of the reticular formation evokes an arousal reaction and increases excitability by lowering the thresholds of sensation (Lindsley, 1960). Consequently, activation of the cortex results. Conversely, lesions in the same area lead to a sharp decrease in the tone of the cortex and a state of sleep results. An arousal reaction in animals with such lesions has not been demonstrated (Lindsley _et al._, 1949; French, 1952, Luria, 1973).

In addition to having an activating function, the reticular formation has an inhibitory one. Stimulation of other parts of the reticular formation has resulted in cortical activity becoming sleep-like, as evidenced by the EEG patterns, often resulting in sleep. In fact, Luria (1973) describes how the Russian surgeon Burdenko, during neurosurgery, would artificially produce a state of sleep in his patients by stimulating the reticular formation.

Contrary to earlier beliefs that the reticular formation was nonspecific and that the main function was to regulate sleep and waking,

research has shown that the reticular formation has certain features of 'differentiation' or 'specificity' in regard to both its anatomy, source and manifestations. There are three primary sources of activation. The first source of activation is that of metabolism, the processes involved in the maintenance of homeostasis. While all metabolic processes are governed principally by the hypothalamus, stimulation of the reticular formation has led to the activation or blocking of metabolic processes. The reticular formation of the medulla and mesencephalon are closely connected with information integration, which leads to activation manifested in the orienting reflex (OR). The OR will be discussed in detail later; suffice it to say now that the OR provides the required alertness for an individual to cope with the constantly changing environment. The third source of activation is evoked by intentions and plans that are formed during consciousness, the motivation of which is social in nature, and which are effected initially by external and then by internal speech. Luria (1973) explains:

> Every intention formulated in speech defines a certain goal and evokes a program of action leading to their attainment of that goal. Every time a goal is reached, the activity stops, but every time it is not reached, this leads to a further mobilization of efforts (p. 57).

This is not entirely an intellectual act, for to initiate and carry out plans, a certain amount of energy is required, and this energy can only be maintained when an individual is at a certain level of activation. The source of this energy is obtained from the cortex which influences the reticular formation via the DRAS.

Arousal and learning problems

Since the 1960's, an arousal deficit has been implied by many researchers as the possible cause of difficulties in learning. An overview of these studies shows the increasing concern for an arousal concept. Berkson (1961) reviewed studies of responsiveness in the mentally deficient, which included such aspects as patellar reflex, galvanic skin response (GSR), alpha blocking and startle reflex. In discussing these studies, considerable time was given to Lindsley's (1957) belief that mental retardation may be the result of an impaired ARAS. Holden (1965) studied the speed of response to three different stimuli--visual, auditory and cutaneous--presented in three different ways: (1) each stimulus singly, (2) the three stimuli randomized over trials, and (3) the three stimuli presented simultaneously on each trial. Results showed no differences between the trimodal random and unimodal stimulus groups, this being interpreted as supporting a subnormal prestimulus arousal hypothesis.

Baumeister and Ellis (1963) found that distracting stimuli tended to facilitate rather than interfere with the performance of retardates in a delayed response task. They interpreted their results in terms of an arousal deficit.

Horowitz (1965) reviewed theories of arousal in an attempt to integrate arousal theory with a developmental retardation point of view, and suggested that mental retardation is a function of stimulation offered by the environment as it interacts with the arousal characteristics of the infant. At the conclusion, Horowitz suggests that mental retardation may be reduced by proper adjustment of the

environmental stimuli.

Clausen (1966), at the conclusion of the Ability Structure Project, indicated that retardates do not control their own level of arousal to the same extent as do normals, and lack the readiness to respond to outside stimuli. Baumeister and Kellas (1968), in their extensive review of reaction time in mental deficiency, also suggest an arousal deficit: "Enough evidence has been presented to lead to the tentative conclusion that retardates suffer a prestimulus arousal deficiency or attentional lag (p. 188)." This deficiency was related to impairment of the ARAS.

Hermelin and O'Connor (1970) reviewed psychophysiological studies in mental retardation and their findings indicated "the possibility of unusual levels of arousal in subnormal and severely subnormal subjects (p. 146)". Whether there are high levels of arousal characterized by high basic GSRs or low levels as shown by short duration of alpha rhythm interruptions after light signals, both deviate significantly from normal expectancy. Hermelin and O'Connor conclude that:

1. Unusual levels of arousal contribute to psychological deficit.
2. Theories are hardening in the direction of supposing arousal levels to differ between subnormals and normals in relation to both CNS and ANS.
3. If arousal and expectations are to be related to cognitive impairment in the mentally retarded, then the measures, like anticipatory response and evoked cortical potentials, will become relevant.
4. Some attempt at subclassification on the basis of different brain pathology should be made.

Meldman (1970) also subscribes to an arousal deficit in the retardate. He describes mental retardation as "mental hypo-attentionism", exhibiting a low arousal and low selectivity of attention. Berlyne (1960) indicates that different levels of arousal might well have a negative effect on learning. He says:

> There is an optimum influx of arousal potential. Arousal potential which deviates in either an upward or a downward direction from this optimum will be drive-inducing or aversive. The organism will thus strive to keep arousal potential near its optimum (p. 194).

Thus, hyperkinesis might well result from a state of overarousal, since defective cortical inhibition might cause an organism to try and reduce the arousal level by seeking stimulation which could eventually induce cortical inhibition. The hyperkinesis might well be considered a manifestation of this stimulation.

Wender (1971), in describing minimal brain dysfunction (MBD), enters into a discussion of an arousal deficit. He proposes three major psychological variants found in MBD: (1) decreased experience of pleasure and pain, (2) extraversion, and (3) a generally high and poor level of activation. Boydstrun, Ackerman, Stevens, Clements, Peters and Dykman (1968) studied 26 children with learning disabilities in a conditioning and generalization procedure. The subjects were required to learn which of two tones signaled the reward of a penny. Throughout the experiment, heart rate, skin resistance and muscle action potential were recorded. Only 62% of the experimental group reached the criterion of five consecutive correct responses, while 92% of the controls did. The results were discussed in terms of an arousal deficit or the combination of it with poor perceptual and motor systems. Cohen and

Douglas (1972) and Satterfield and Dawson (1971) further subscribe to an arousal deficit as an underlying cause of learning problems. Satterfield and Dawson (1971), for example, examined the GSR of 24 hyperactive children. The hyperactive children were found to have lower basal skin conductance levels, fewer nonspecific GSRs and smaller magnitude of GSR to repeated sounds of 50 dB. These results were contrary to their hypothesis, and offered the hypothesis that the reduced GSR activity was due to a lowered excitability of the reticular activating system. Cohen and Douglas (1972) also compared hyperactive and normal children on GSR measures. They reported:

1. No significant difference in resting levels, amplitude of response or rate of habituation;
2. Significantly smaller specific responses in the hyperactive group in a reaction time task.

The general belief of higher than normal arousal level in hyperkinetic children appears to be in conflict with the findings of Cohen and Douglas (1972) and Satterfield and Dawson (1971). Possible individual variability in hyperactive groups or some procedural differences might explain this conflict. However, Satterfield and Dawson (1971) suggest that hyperactivity is secondary to a condition of low arousal, and represents the low aroused child's attempt to seek an increase in sensory input via the proprioceptors and extereoceptors. The fact that this discrepancy exists warrants further investigation into autonomic activity and hyperkinesis.

An approach that might well be fruitful is that of Luria (1961, 1963), who considered children with learning problems to differ in

levels of arousal. His theory will now be considered.

Luria's clinical classification

The roots of Luria's classification can be traced to Pavlovian theory. Pavlov (1928, 1941) contends that nervous processes can be divided into two categories, excitatory and inhibitory, and that they are reciprocal. As originally expounded by Pavlov (1928), cerebral excitation is a result of stimulation which is directly followed by inhibition in the same area and induces inhibition in surrounding areas. Thus, there is an excitation-inhibition balance which exists temporarily for any given region and spatially for a broader area. Pavlov (1928) explains:

> It is highly probable that excitation and inhibition, the two functions of the nerve cell which are intimately interwoven and which so constantly supercede each other, may fundamentally represent only different phases of one and the same physicochemical process (p. 378).

This mode of excitation-inhibition of Pavlov has provided a sound basis for Luria's research with children experiencing learning problems (Luria, 1961, 1963). In order for normal mental processes to occur, a sufficient strength, balance and high lability of the nervous processes is required. A weakness in any one of these areas will result in some kind of learning problem. Luria has therefore attempted to classify children in terms of strength, balance and lability of the nervous processes. If the strength of the nervous processes decreases, the brain cannot maintain the necessary level of excitation in the nerve cells, nor the required intensity of the inhibitory process (Luria, 1963). If normal balance of the excitatory and inhibitory processes is disrupted,

two distinct patterns of behavior result:

1. If excitatory processes are affected, the person becomes listless, exhausted and easily inhibited, and habituates readily.
2. If inhibitory processes are affected, the patterns of behavior that are commonly seen are restlessness, excitability, poor control and impulsiveness.

Lability is the ability of cortical nervous processes to easily change from a state of excitation to inhibition. In pathological conditions, the brain is unable to switch quickly from one state to the other, which often results in 'fixated' forms of behavior. Thus, lost lability refers to a kind of 'inertness'.

Therefore, children with learning problems, whether they are mentally retarded or learning disabled (the latter group is referred to by Luria as "cerebroasthenic" [1961]) can be divided into three basic categories:

1. The excitable type: children in whom excitation predominates.
2. The inhibitory type: children in whom inhibition predominates.
3. The balanced type: where there is an absence of pronounced dominance of excitation or inhibition but both processes are weak.

Luria describes the characteristics of these children in terms of certain motor responses during conditioning and discrimination tasks. For example, the excitable child has extreme difficulty in switching to an inhibitory response during discrimination experiments (Luria, 1961), while the inhibitory child is unable to respond correctly to positive or negative signals in different conditions. The explanation for this behavior is that the necessary motor responses to short positive

signals soon begin to disappear, which is also accompanied by a general diffuse inhibition resulting in a complete disappearance of any reaction to either positive or negative signals.

This classification has also been used by the Russian psychiatrist Pevzner (1959), who in his book Oligophrenia: Mental deficiency in children discusses several case studies emphasizing the characteristics found in each group.

It is surprising that this classification has not attracted the Western researcher, since research has shown that individuals do differ on varying levels of arousal from low to high (Berlyne, 1961). It is true that many studies have investigated high arousal levels under the label of hyperkinetic or hyperactive behavior, but research into states of hypoarousal is sadly lacking. However, the writer was able to find three studies involved with levels of hypoarousal which might suggest that Western interest may be going in this direction. Browning (1967), while investigating hyperactivity in terms of responsiveness, found that exaggerated responsiveness to stimuli occurred without apparent increases in motor activity and coined the phrase "hypo-responsiveness". He further found that some 'brain-damaged' children were not more distractible than normal and then formulated a hypothesis of 'hypo-responsiveness'. Dykman, Walls, Suzuki, Ackerman and Peters (1970) and Anderson (1973) divided children with learning problems into three groups: hyperactive, normoactive and hypoactive. Results in both studies found that hyperactive and hypoactive do differ on several measures and suggest that future research investigate different levels of arousal and related behavior in children with learning problems.

Measurement

Assessment techniques for hyperkinesis are many and varied, but tend to concentrate more on the activity level of hyperkinesis than on the other behaviors that are incorporated in this syndrome. Because of the excellent review by Werry and Sprague (1970) on assessment techniques, only a brief overview of the inadequacy of present-day techniques will be given.

Behavioral measures

1. Rating scales. A common method is to utilize a rating scale that includes the behaviors that are part of the hyperkinetic syndrome (Werry & Sprague, 1970; Bell *et al.*, 1972). These rating scales can be given to parents and teachers who are familiar with the child. While the virtue of these scales lies in their simplicity and inexpensiveness (Werry & Sprague, 1970), certain disadvantages prevail:

(a) It may require extensive experience with the child in order to rate him.

(b) It relies on the judgments of parents and teachers whose basis for rating the child might be completely different.

(c) The ratings might be influenced by reference to the child's peer group.

Another kind of rating scale is the checklist--the direct observation of motor activity by observers. In this technique the child is observed for a unit of time, typically subdivided into cells of a few seconds duration, during which particular motor behaviors are recorded. At the end of the session the cells are then combined over the total time period to give a questionnaire score. The place of

observation can be either a place of familiarity to the child, his classroom (Patterson, Janes, Whittier & Wright, 1965) or a laboratory situation (Hutt, Hutt & Ounsted, 1965). The weakness of this technique relates to the problems of adequate sampling of the child's behavior.

2. Objective measures. Here activity is measured directly by mechanical or electrical means. Cromwell, Beaumeister and Hawkins (1963) review the methodologies up to that time and describe five methods of measuring activity: direct visual observation, a free-space traversal approach and the use of a kinetometer, a fidgetometer and a ballistograph. Since this review, other devices have been developed, such as an ultrasonic device (McFarland, Peacock & Watson, 1966), FM telemetric devices (Herron & Ramsden, 1967) and films (Lee & Hutt, 1964). A number of advantages are attributed to these methods, particularly the fact that the researcher does not require any previous knowledge of the child and that the measurements produce quantitative data that does not rely on the researcher's judgment. However, one of the main disadvantages of these techniques, as pointed out by McConnell *et al.* (1964) and Sprague and Troppe (1966), is that the predictive validity of such tools is poor when validated against rating scales for hyperkinesis. The reason for this is that the tools measure activity level and do not include other behaviors of the hyperkinetic syndrome. Furthermore, from the practical point of view, these tools are usually cumbersome and expensive.

Neurophysiological measures. In the diagnosis of hyperkinesis, Werry (1968) states that the use of the electroencephlogram (EEG) and the neurological examination are of little use. Laufer and Denhoff

(1957), Clements and Peters (1962) and Werry, Weiss and Douglas (1964) have shown that the majority of nondefective, nonepileptic hyperactive children either have normal EEGs and neurological examinations or minor abnormalities which are of uncertain cause and significance. Attempts to relate these minor EEG and neurological abnormalities have generally produced a lack of such relationship (Schulman et al. (1965). Commenting on these results, Werry (1968) says:

> Perhaps this is because the abnormalities of the neurological examination seem largely to be clumsiness (or mild apraxia) and slight agnosias which fall in the gray area of soft or equivocal neurological signs and which must not in the present state of knowledge be accorded the status of major neurological signs. The neurological significance of these abnormalities as commonly found in hyperactivity must be considered still 'sub judice' and not evidence of definite cerebral damage or even established dysfunction (p. 178).

To measure arousal, it is important to have a relatively simple measure. As indicated above, the EEG technique is questionable; therefore autonomic activity might be considered. Research has shown that autonomic activity is a good indicator of arousal, particularly the GSR. A brief review of the GSR as an arousal indicator will now follow.

Galvanic skin response (GSR): An arousal indicator. Electrodermal measures today are accepted as good indices of arousal (Edelberg, 1970) and the most useful and widely used index has been the GSR (Hermelin & O'Connor, 1970). The GSR is determined by the permeability of the cell membranes of the skin, especially of the sweat glands (Forbes, 1964). Control of this permeability is a function of the sympathetic nervous system, which in turn, according to Wang (1964), is governed to a large extent by the reticular formation. Dell (1963) reports that on direct

stimulation of the reticular formation, various autonomic activities occur, including the appearance of a GSR. Furthermore, the GSR occurs on the periphery of the body and Stennett (1966) states that for a peripheral indicator of arousal three characteristics are desirable:

1. For every change in the state of the organism there should be a detectable change in the peripheral measure.
2. Great changes in the state of the organs should produce correspondingly great changes in the peripheral measure.
3. Increased excitation of the organism should be accompanied only by increases in the values of the peripheral measure.

With these three characteristics, the GSR appears to be the most suitable measure.

One way of measuring the GSR is by investigating the orienting response (OR). Initial investigation of the OR was conducted by Pavlov (1928, 1941), who referred to it as the "What is it" reaction. Since Pavlov, many research workers both in the Soviet Union and the Western world have studied it (Berlyne, 1960; Luria, 1963; Lynn, 1966; Maltzman & Raskin, 1965; Sokolov, 1960, 1963, 1969). The OR comprises a number of components, including increased sensitivity to sense organs, changes in skeletal muscles that direct sense organs, EEG changes, together with autonomic changes such as heart rate and GSR. This system of responses appears to have the effect of facilitating stimulus reception and stimulus response. The most comprehensive model of the OR has been advanced by Sokolov (1960, 1969) (see Figure 5). According to his theory, incoming stimuli are analyzed in the cortex and, upon analysis, the cortex inhibits or excites the reticular formation. The model

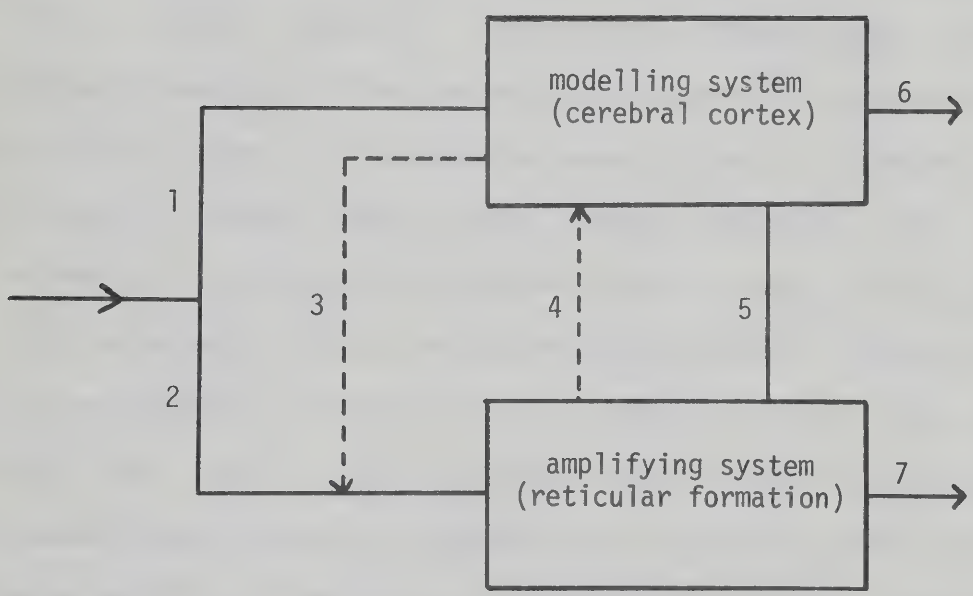


Fig. 5. Sokolov's model for the orientation reaction

1. specific pathway from sense organs to cortical level of modelling system. 2. collateral to reticular formation. 3. negative feedback from modelling system to synaptic connections between collaterals from specific pathway and reticular formation (RF) to block input in the case of habituated stimuli. 4. ascending activating influences from the RF to the modelling system (cortex). 5. pathway from modelling system to amplifying system; this is the pathway through which the impulses signifying nonconcordance between input and existing neuronal models are transmitted from cortex to RF. 6. to specific responses caused by coincidence between the external stimulus and the neuronal model (habitual response). 7. to the vegetative and somatic components arising from the stimulation of the RF (from Lynn, 1966).

assumes the presence of a screening and an amplifying system in the cortex. The screening system postulates the existence of a "chain of neural cells which preserve information about the intensity, the quality, the duration and the order of presentation of the stimuli (1960, p. 205)". Therefore, if an arriving stimulus does not match the stored information in the screening system, an OR is produced via the amplifying system. In addition to sensory stimuli, the model is capable of handling complex stimuli such as symbols and words. Thus, when information is gained which requires analysis there is an OR, elicitation of which occurs through unexpected stimulus change, including the presentation or termination of a stimulus (Berlyne, 1960; Sokolov, 1963; Stern, 1968). The activation of the reticular formation by the screening model occupies a central role in Sokolov's model (Lynn, 1966). The reliability of the GSR as a component of the OR has been widely supported (Clausen & Karrer, 1968).

The GSR as an arousal index has been studied in most forms of psychopathology. Extensive reviews of research involving mental retardates, schizophrenics and children with minimal brain dysfunction can be found in Karrer (1966), Depue and Fowles (1973) and White (1974), respectively. Details of such studies are discussed in Chapter III, and it is sufficient to state at this point that arousal is indexed by the GSR in normal and pathological states.

In summary, this section has considered the nature and mechanism of arousal, its relationship to difficulties in learning and the problems inherent in its measurement, both behaviorally and physiologically.

Information Processing

The importance of individual differences in information processing is discussed in this section. Many theories have been developed to explain individual differences and are often referred to as theories of 'cognitive style', examples of which are Kagan's theory of Reflectivity-Impulsivity (Kagan, 1965) and Witkin's theory of Field Dependence-Independence (1962). This discussion, however, will focus on a model of cognitive ability (Das, Kirby & Jarman, 1975) that is based on the theory of Simultaneous and Successive Synthesis developed by Luria (1966a, 1966b). In order to understand the problems encountered by children with learning disabilities, Chalfant and King (1976) and Ross (1976) advocate more research into information processing, whereby the child's problem can be identified directly in terms of a specific processing dysfunction. Consideration of the model of Das, Kirby and Jarman (1975) appears to be a step in this direction.

Biggs (1971) defines cognition as "the sum total of all the processes that govern the input of information, its transformation and storage, and its recovery and use. Perception learning, problem-solving, hallucinating and so on, are all cognitive processes (p. 120)". Most psychologists would agree with this definition and in doing so further emphasize the importance of research into the understanding of cognitive processes. This is certainly not a new field of study, for Sir Francis Galton and James McKeen Cattel investigated individual differences in terms of cognitive functioning. Cattel (1890), for example, proposed ten tests that could be used to evaluate differences among people. The

procedure he used included least noticable difference in weight, reaction time to sound, judgment of 10 seconds time, number of letters remembered on one learning and time for naming colors. However, renewed interest in individual differences since the 1950's has centred on language, reasoning, perceptual synthesis and decision processes.

Messick (1972, 1973) indicates that cognitive style includes a "person's typical modes of perceiving, remembering, thinking and problem solving". Kagan, Moss and Sigel (1963) spoke of "stable, individual preferences in mode of perceptual organization and conceptual categorization of external environment (p. 8)". While Coop and Sigel (1971) referred to cognitive style as "consistencies in individual modes of functioning in a variety of behavioral situations (p. 152)", the early work of Gardner (1953, 1959, 1961) and his colleagues (Gardner, Jackson & Messick, 1960) indicated that a number of 'cognitive controls' were responsible for the ways in which individuals select, order and program information. Witkin and his associates (Witkin, Dyk, Faterson, Goodenough & Karp, 1962; Witkin, Lewis, Hertzman, Machover, Messner & Wagner, 1954) originally emphasized aspects of perceptual organization, but expanded their approach to include cognitive functions, which they called "global-analytic styles of field articulation".

In a general sense, then, cognitive style refers to individual differences in information integration in a variety of task situations. Kogan (1971), in his article "Educational implications of cognitive styles", indicates that cognitive constructs have been variously labelled as styles, controls and strategies and that "these conceptual distinctions are more a matter of differences in theoretical orientation

of the investigator than of differences in the phenomena (p. 245)". From this point on, the term cognitive strategy will be used to refer to individual differences in information integration.

The awareness of differences in cognitive strategies is of utmost importance in education, particularly when one deals with the problems of learning in exceptional children. Individual differences in cognitive strategies are clearly important in school learning, since certain aspects of cognitive strategies are part of attention and information integration. Kagan, Rosman, Day, Albert and Phillips (1964) noted that "pedagogical procedures should acknowledge the interaction between the dispositions of the learner and the material, and tailor presentations to the preferred strategy of the child (pp. 35-36)". Coop and Sigel (1971) suggest that consideration of cognitive strategy may well provide more sensitive data for education in terms of individual instructional programs, while Messick (1972, 1973) proposed that cognitive strategies may interact with instructional variables and treatment,which moderate learning, retention and transfer. Witkin (1965) considered individual differences in cognitive strategy as the basis for educational evaluation, placement and teaching methods.

From the points of view expressed above, it is quite evident that individual differences interact with instructional approaches, which either facilitate or interfere with the learning process. Thus, cognitive strategies should be further investigated as a variable that can be used in the planning of remedial programs for exceptional children. To date, this approach has been limited.

If one looks at the work of Strauss and Kephart (1955), they

observed that the main difficulty of the brain-injured child is in spatial integration, i.e., the inability to see simultaneous relations. Thus, the main characteristics of the brain-injured child, forced responsiveness to stimuli, perseveration, distractibility and figure-ground disturbances can, according to Strauss and Kephart, be traced to the primary disturbance of the child's inability to see simultaneous relations. It would seem that the learning disabled child, in the eyes of Strauss and Kephart, is predominately hyperactive. But if one looks at Luria's classification this is not so. Therefore, it is unlikely that all learning disabled children have problems in spatial integration. The question to be asked now is: How do learning disabled children process information in the light of Luria's classification?

Luria (1966a, 1966b) has developed a theory which suggests that information can be processed in sequence or in parallel form, which Luria calls successive and simultaneous synthesis. The theory has not received much attention outside the Soviet Union apart from the work of J. P. Das (1972, 1973a, 1973b). The results of Das' work warrants further investigation into simultaneous and successive synthesis. In this study simultaneous and successive synthesis are looked upon as cognitive strategies, with the objective of investigating the effects of different levels of arousal on the two forms of synthesis in children with learning problems. What follows is a description of Luria's theory, followed by an analysis of the work of Das.

Luria's theory of successive and simultaneous synthesis

According to Luria, the brain is engaged in two types of integrative activity, simultaneous and successive. Formulation of this hypothesis is based on clinical observations of persons with lesions in the left hemisphere of the cortex (Luria, 1966a, 1966b; Luria & Tzvetoka, 1967). Disturbance of the simultaneous processing of stimuli was found when lesions occurred in the occipito-parietal area, while disturbance of successive processing occurred with lesions in the fronto-temporal area. The processing of information by the brain is accomplished by the use of a series of analyzers--exteroceptive, proprioceptive and interoceptive. Working in unison they synthesize incoming information into various forms. Complex processes such as perceptual activity require the combined working of a group of analyzers in order that signals arriving from several receptors, e.g., skin, muscle, etc., be integrated into a whole dynamic system. This 'afferent synthesis' is mandatory for the normal performance of any higher cortical activity. The analyzers are identified in terms of cortical localization, and the integrative characteristic of their function occurs by the existence of 'overlapping zones'. Thus, Luria points out that the integrative activity of the cerebral cortex consists of two basic forms--simultaneous and successive syntheses.

Simultaneous synthesis. Simultaneous synthesis refers to the integration of different stimuli into simultaneous, primarily spatial groups. Luria hypothesizes that there are three varieties of simultaneous synthesis for it may occur during direct perception, memory or in complex intellectual processes.

1. _Direct perception_. Luria explains:

> When we glance at a complicated picture, we do not at once perceive all its parts, but, examining them gradually, we distinguish their essential elements (those giving maximal information) and we synthesize them into a single entity, a unified visual structure (Luria, 1966b, pp. 74-75).

Luria further adds that this type of formation is primarily spatial in nature, and the same principle may also apply in the 'acoustic analyzer'.

2. _Mnestic processes_. This refers to the ability of a person to recall and organize stimulus traces. An example is when an individual is required to memorize a series of words, repeated several times. The series of words gradually becomes a group that consequently takes on the characteristic of a single simultaneous system.

3. _Intellectual processes_. Luria states that in order that an organism understand any system of relationship, whether it be a grammatical system of language or a system of mathematical concepts, it is necessary that the elements of these systems be represented simultaneously, thus allowing the relationship of the elements to be surveyed and determined.

Successive synthesis. Successive synthesis refers to the ability of the organism to arrange the incoming stimuli in sequence. Luria (1966b) cites Sechenov as describing this ability of the cortex to "integrate external influences or their traces into successive series, distinguishable in time (p. 77)". One of the main distinguishing features between simultaneous and successive synthesis is that in simultaneous processing successive elements are integrated into simultaneous groups and become easily surveyable, while successive processing does not have this property. Instead, a "particular chain of successive links"

activates the components. Similarity does exist between the two syntheses, in that successive synthesis is also identified as possessing three varieties: sensorimotor, mnestic and intellectual.

1. Sensorimotor. This refers to the sequential combination of acts that produces certain forms of skilled movements, e.g., a habit such as walking or writing, habits that are formed gradually. Luria suggests that in the first stages of the formation of a skilled movement, each component link is first seen as a separate motor act, and it is only when the links become automatic that the habit is formed.

2. Mnestic. This is best exemplified by what Luria calls 'rhythmic' or 'tonal melodies', where each tone acts as a cue for the next, thus producing a chain of successive links.

3. Intellectual. This is by far the most complex variety of successive synthesis. An obvious example is human speech as Luria (1966) points out that "the individual elements of the whole narrative always behave as if organized in certain successive series (p. 78)".

Only in the last five years has this theory been investigated to any appreciable extent in a nonclinical population, using methods that do not need painstaking observations of behavioral change following brain damage.

Das (1972, 1973a, 1973b) investigated these processes using factor analytic techniques, the results of which have shown that simultaneous and successive processing emerge as relatively stable factors across cultural groups, age groups, IQ groups and socioeconomic levels. These results have further led to the development of a model of information processing (Das, Kirby & Jarman, 1975) which will now be discussed briefly.

Model of successive and simultaneous syntheses

The model proposes that information integration consists of four basic units: the input, the sensory register, the central processing unit and the output unit. The model is shown in Figure 6.

Stimulus input is considered in two parts. Firstly, a stimulus may enter via any of the receptors (extero-, intero- or proprioceptors) to any one of the sense modalities. Secondly, the input stimulus may be presented in a simultaneous or successive manner. The stimulus is immediately registered by the sensory register and information is passed on for central processing. The unit of central processing has three components, two processing and a decision and planning component. The two processing components are: (1) when separate information is passed into simultaneous groups, and (2) when information is processed into temporarily organized successive series. Das *et al*. (1975) point out that the processing in these components is not affected by the way in which the sensory input is processed. The reason being that, according to Luria (1966b), the processing components are associated with specific parts of the cortex--the successive synthesis occurs in the fronto-temporal area of the anterior cortex and simultaneous synthesis occurs in the occipital-parietal area. Both of these areas are concerned with the storing and coding of information and do not regulate or control conscious behavior, a function that is confined to the frontal lobe.

A basic assumption underlying the model is that the selection of either of the processes that are available to each individual depends on: (1) the habitual mode of information processing of the individual "as determined by social-cultural and genetic factors (Das *et al*. (1975)",

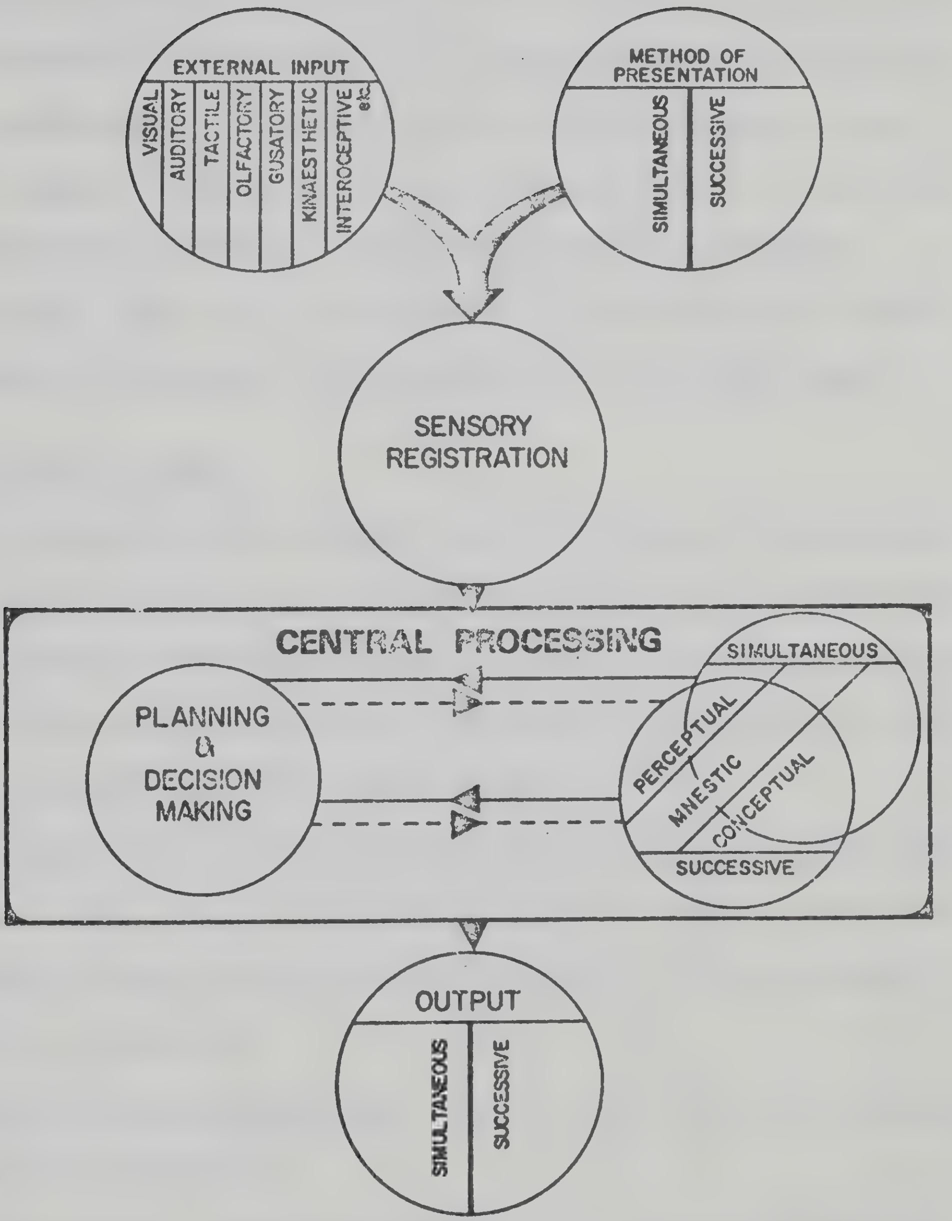


Fig. 6. Model of information integration

and (2) the nature of the demands of the task.

The third component, the decision and planning part, which could also be labelled 'thinking', utilizes the coded information from the other two components and determines the best possible way to react.

The nature of the response in the output unit may be successive or simultaneous, regardless of their original method of input presentation. Thus, it is the output unit that regulates the type of performance in accord with the requirements of the task at hand.

Factor analytic studies

As previously stated, evidence for the presence of simultaneous and successive synthesis and the model of Das, Kirby and Jarman (1975) has been obtained from factor analytic studies. Only a brief discussion of some of the studies will follow, the reader being referred to the original sources (Das, 1972, 1973a, 1973b).

In order to test for the presence of the two processes, Das has developed a test battery for use in his studies. While a detailed description of some of the tests will come later, a brief mention of the tests is called for.

Raven's Progressive Matrices. This is a well-known test measuring reasoning and abstraction.

Graham-Kendall's Memory for Designs. This test was originally constructed to distinguish between organic and nonorganic subjects.

Cross-modal coding test. Adapted from the work of Birch and Belmont (1964). The subject listens to a pattern of sounds, following which he is asked to recognize visually which of the three dot patterns

resembles the auditory stimuli.

Short-term memory (visual) test. The subject is presented separately with 20 five-digit grids. The subject views the five digits for 5 seconds and then is asked to reproduce them immediately on a response sheet.

Auditory serial recall. Subject is asked to recall short word lists of four words that sound the same.

Free recall. Subject is asked to recall short word lists of four words that are semantically similar.

Molloy (1973) investigated socioeconomic states and simultaneous and successive synthesis, the results of which are found in Tables 2a and 2b. In addition to simultaneous and successive factors emerging, a speed factor emerged. The tests used for speed were word reading and color naming, tasks adopted from the Stroop (1935) test. In the study, 60 low SES children and 60 middle SES children were used. Both samples came from Grade 4 and were approximately 10 years old.

Investigating simultaneous and successive synthesis across culture, Das (1973a) found the three factors to emerge again. These results are shown in Tables 3 and 4.

The most recent evidence of simultaneous and successive factors is found in Tables 5a and 5b. These results are from a study carried out by Jarman (1975) who investigated the relationship between IQ, information processing and modality matching. For the low IQ group, the successive factor is found in serial and free recall tests, while the simultaneous factor was defined by Raven's Progressive Matrices, Figure Copying and Memory for Designs tests. The speed factor was

Table 2a

Rotated Factors for High SES Grade 4 Children (N = 60)

Variables	I Successive	II Simultaneous	III Speed
Progressive Matrices	121	845	-058
Figure Copying	125	755	110
Memory for Designs	189	-788	-052
Cross-modal coding	063	492	677
Word reading	-106	119	-805
Visual short-term memory	555	087	629
Serial recall	962	022	135
Free recall	959	024	121
Variance	2.234	2.171	1.553

Table 2b

Rotated Factors for Low SES Grade 4 Children (N = 60)

Variables	I Successive	II Simultaneous	III Speed
Progressive Matrices	150	847	201
Figure Copying	-010	682	013
Memory for Designs	110	-769	219
Cross-modal coding	541	430	334
Word reading	-131	-030	914
Visual short-term memory	714	-069	-360
Serial recall	921	011	-015
Free recall	935	014	-004
Variance	2.548	1.965	1.166

Table 3

Rotated Factors (Varimax) for Cognitive and Achievement Tests: Edmonton High and Low SES Children (N = 60)

Variables	I Successive	II School Achievement	III Simultaneous	IV Speed
IQ (from school records)	347	793	204	045
Progressive Matrices	181	384	740	200
Figure Copying	162	157	674	004
Memory for Designs	178	-055	-830	-162
Cross-modal coding	457	059	433	423
Visual short-term memory	760	034	124	462
Serial recall	896	355	042	013
Free recall	898	340	004	019
Word reading	-130	-320	045	-879
Reading achievement	184	851	100	266
Math achievement	161	844	281	152
Variance	2.684	2.590	2.029	1.328

Table 4

Rotated Factors (Varimax) for Cognitive Tests:
Brahmin Children (N = 90)

Variables	I Successive	II Simultaneous	III Speed
Word reading	-011	830	032
Progressive Matrices	624	253	433
Figure Copying	800	-278	-112
Memory for Designs	-809	111	-037
Cross-modal Coding	206	-640	233
Visual short-term memory	-013	175	918
Variance	1.726	1.282	1.099

Table 5a

Principal Components with Varimax
(Verbal IQ Range: 71-90; Performance IQ Range: 66-95)

Variables	Communalities	I Successive	II Simultaneous	III Speed
Progressive Matrices	371	-115	594	077
Figure Copying	570	077	751	-033
Memory for Designs	683	-097	-821	-002
Serial recall	935	955	044	143
Free recall	942	958	-005	159
Visual short-term memory	704	084	231	802
Word reading	732	-199	181	-812
Variance	4.939	1.905	1.678	1.356

Table 5b

Principal Components with Varimax
(Verbal IQ Range: 111-130; Performance IQ Range: 106-135)

Variables	Communalities	I Successive	II Simultaneous	III Speed
Progressive Matrices	679	-210	778	-171
Figure Copying	625	-040	511	602
Memory for Designs	615	-161	-758	-121
Serial recall	813	861	-007	-266
Free recall	885	915	094	-195
Visual short-term memory	468	655	-103	169
Word reading	695	-122	-115	816
Variance	4.779	2.095	1.474	1.210

obtained from the visual short-term memory test and the word reading test. The same factors emerged for the high IQ group, the only change being that the Figure Copying test loaded on the speed factor as well as the word reading test.

From these factor analytic studies and other studies reported by Das (1972, 1973a, 1973b) and Krywaniuk (1974), it is evident that simultaneous and successive synthesis "offer an alternative way of categorization of cognitive abilities (Das, Kirby & Jarman, 1975)". Of central importance to this study is the attempt to determine the pattern of cognitive abilities in the different types of learning disabled children, whether a pattern is unique to one group. Such information will provide the basis for future investigations which will be important in terms of remedial instruction. For example, if hyperkinetic children are found to do poorly on simultaneous tasks, then remedial methods should emphasize tasks that are successive in nature.

CHAPTER III

DEFINITIONS, HYPOTHESES AND RATIONALE

Statement of Problem

The study addressed itself to the problem of learning disabilities in children. The problem consisted of several interrelated questions:

1. Do children with learning disabilities differ in arousal levels?
2. What measures best discriminate between different levels?
3. What relationship exists between physiological and behavioral arousal?
4. Is there any difference in information integration between children who differ in arousal levels?

Arousal and Arousal Measures

The term arousal has become very popular in referring to the behavior of individuals since it has a firm basis in both physiology and in describing behavior. The term, however, has had its problems, mainly semantic in nature (Andrews, 1974), and in order that such confusion be avoided in this study, a distinction must be made at the outset of this chapter in the hope that clarity will prevail for the remainder of the study. In terms of physiology, arousal will be referred to as physiological arousal (PA) and varying degrees of PA will be designated as follows:

physiologically overaroused	POA
physiologically normally aroused	PNA
physiologically underaroused	PUA.

From the behavioral point of view, behavioral arousal and the different levels thereof shall be referred to as follows:

high behavioral arousal	hyperkinetic
normal behavioral arousal	normokinetic
low behavioral arousal	hypokinetic.

From the literature review, one notices the virtual absence of studies comparing children with different levels of arousal. Despite the work of Luria (1960, 1973), who has established the fact that children do differ in arousal levels, researchers have been slow in accepting this fact. In mental retardation research, studies have generally found the mentally retarded to be PUA, but it would be a mistake to assume that all mentally retarded show less PA than normals (Clausen, 1973). Similarly, children with learning disabilities are invariably described as hyperkinetic and only a few studies have identified hypokinetic subjects (Boydstrun *et al.*, 1968; Anderson, Halcomb & Doyle, 1973). There is a need for the recognition of learning disabled children who are not hyperkinetic. From the work of Strauss (Strauss & Lehtinen, 1947; Strauss & Kephart, 1955) it would appear that all children with learning disabilities are hyperkinetic. However, if one turns to Luria's classification, some learning disabled children are hypokinetic. This has been borne out by Boydstrun *et al.* (1968) and Anderson *et al.* (1973) who showed that hyperkinetic and hypokinetic children do differ on several measures. Knowledge of the existence of such differences will provide valuable information concerning diagnosis and remedial instruction.

Eysenck (1967) hypothesized that cortical excitation is behaviorally

manifested as the inhibition of autonomic responses. In contrast, Das (1973) suggests that cortical inhibition is manifested in behavioral arousal or an augmentation of autonomic activities. Thus, the brain-damaged child studied by Strauss might well be cortically inhibited (Das, 1973). These theoretical formulations and the recent findings of Satterfield (Satterfield & Dawson, 1971; Satterfield, Atonian, Brashears, Bierleigh & Dawson, 1974) suggest that behavioral arousal might not reflect the state of arousal physiologically. If this is indeed the case, then one should at least use both a physiological and a behavioral measure of arousal when investigating states of arousal in children, even more so in children with learning disabilities. Such an approach will hopefully reduce the existing confusion that surrounds a child with a learning disability. Therefore, two arousal measures were used: (1) the GSR, the physiological measure; and (2) a child rating scale, the behavioral measure.

The rationale for using the GSR as an index of physiological arousal has already been discussed in Chapter II. What follows is a discussion of the components of the GSR that might be expected to discriminate between levels of PA. The following components will be considered: spontaneous fluctuations, habituation rate, latency, recovery limb, magnitude, and basal level.

GSR definition

A GSR is defined as any downward pen deflection of 500 ohms change or more commencing 1-5 seconds after the onset of the stimulus (see Figure 7).

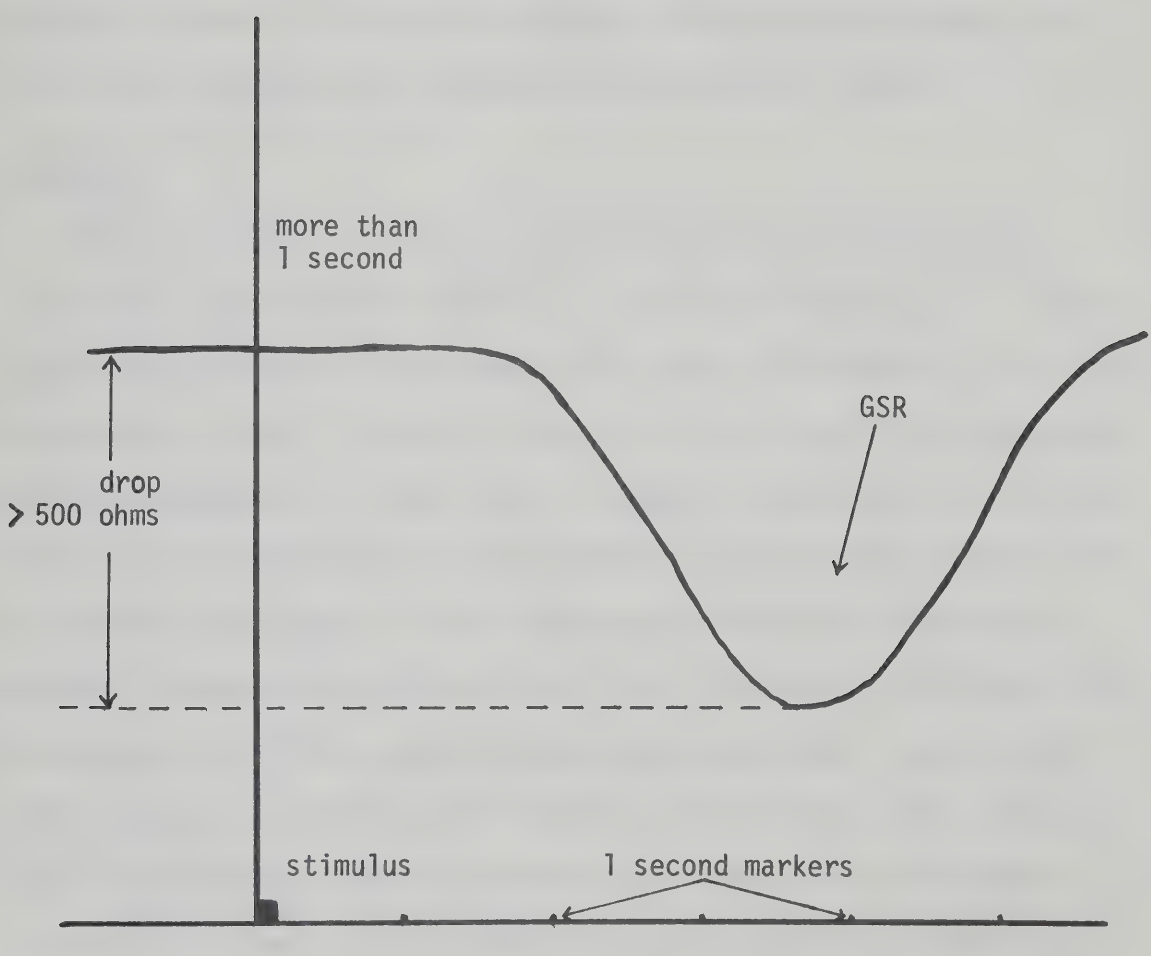


Fig. 7. Identifying a GSR

Spontaneous fluctuations: Definition

Lacey and Lacey (1958) describe this as periodic oscillatory changes that are not correlated in time with specific stimuli or with detectable specific episodes of affective response. Spontaneous GSRs have also been called 'nonspecific' responses (Burch & Greiner, 1960).

Rationale

Martin (1973), in reviewing somatic reactivity, indicates that "spontaneous physiological activity, in particular the GSR, is a measure that shows meaningful relationship with arousal, performance, stimulation and stress (p. 314)". Several research workers believe that spontaneous GSRs are proportional to the level of arousal. Burch and Greiner (1960) varied the arousal levels of their subjects with the drugs pentothal and epinephrine, and found that the frequency of spontaneous GSRs was a monotonic increasing function of the level of arousal. Silverman, Cohen and Shonavonian (1959), investigating spontaneous GSRs, reported that when subjects were alerted, the frequency of spontaneous GSRs increased. Surwillo and Quilter (1965) researched spontaneous GSRs and degree of vigilance, and their results seemed to indicate that the frequency of spontaneous GSRs can be used as a reliable index for general level of arousal.

Investigating brain-damaged patients, Parsons and Chandler (1969) found a higher incidence of spontaneous GSRs in the experimental subjects than the controls, and a similar finding is reported by Brivolla (1965). However, Satterfield and Dawson (1971) studied the GSR in 24 hyperactive children and their matched controls. Contrary to their hypothesis, they found that the hyperactive group had less spontaneous GSRs. Karrer and

Clausen (1964) report that significantly more controls than mentally retarded subjects showed spontaneous activity, whereas Das and Bower (1971) found the opposite. These discrepancies point very strongly to the existence of different levels of arousal.

Hypothesis 1.1. The POA subjects will show more spontaneous GSRs than the PUA and PNA children.

Hypothesis 1.2. The PNA will show more spontaneous GSRs than the PUA.

Hypothesis 1.3. The PNA and control subjects will not differ in spontaneous GSR frequency.

Habituation rate: Definitions

Habituation: has been defined by Thompson and Spencer (1966) and Groves and Thompson (1970) as a response decrement to repeated stimuli.

Habituation rate: is measured as both number of trials and period of time in seconds from the stimulus onset to the third consecutive no-response trial (Barham, 1971).

Rationale

In mental retardation studies, the use of habituation rate has been used to determine whether the mental retardate's impairment is reflected in a simple form of learning (Stern & Janes, 1973). Generally speaking, most studies report little or no difference between mentally retarded subjects and normals in habituation rate (Das & Bower, 1971; Wolfensberger & O'Connor, 1965; Karrer & Clausen, 1964). However, two studies (Tizard, 1968; Fenz & McCabe, 1971) have found differences. Possible explanations are that Tizard used severely retarded subjects (IQ 20-30) that were hyperactive, and Fenz and McCabe used different data evaluation methods.

However, differences can be expected in habituation rates between groups if one looks at Nebylitsyn (1973), Kesner (1973), Boydstrun _et al_. (1968), Brivllova(1965), and Stepanov (1965). Nebylitsyn (1973), who discusses the work of Mundycastle and McKiever (1953) and Voronin, Sokolov and Pao-Hua Wo (1959), says that slower habituation of the GSR component of the OR reflects high dynamism of excitatory processes. Brivllova (1965) and Stepanov (1965) both investigated brain-damaged patients and found that the habituation rate of the ORs of their subjects were slower than normals. Boydstrun _et al_. (1968) found a slower rate of habituation in minimal brain-damaged subjects than normals. Furthermore, one finds the suggestion in Kesner's (1973) article that differences in OR as a result of arousal levels might be expected. Kesner points out that a state of high arousal leads to a faster decay of short-term memory, which in turn should lead to a reduction in habituation rate of the OR.

Hypothesis 2.1. POA children will show a slower rate of habituation than PUA and PNA children.

Hypothesis 2.2. PUA children will habituate faster than the PNA children.

Hypothesis 2.3. PNA children will not differ in habituation rate from control subjects.

Latency of response: Definitions

Latency of response is the time from stimulus onset to response onset. There are two types of latency for each GSR identified.

Latency 1: from the stimulus onset to the start of the GSR deflection drop.

Latency 2: from the start of the GSR deflection to the point of maximum drop.

Figure 8 depicts latency 1 and latency 2.

Rationale

The majority of studies investigating latencies have used mentally retarded subjects, the rationale being that the sluggishness of this population in more complex behaviors might be evident in simpler autonomically mediated responses (Stern & Janes, 1973). Karrer (1966), Galkowski, Diadas and Domanski (1968), Clausen and Karrer (1969), Wolfensberger and O'Connor (1965) have all found that the mentally retarded subjects have shorter response latencies than normals. Closer scrutiny of these studies shows gross errors such as misinterpretation of data, misinterpretation of results of other investigators (Stern & Janes, 1973). In fact, most studies really show no differences in latencies between mentally retarded and normals when presented with simple stimuli (Wolfensberger & O'Connor, 1965) and complex stimuli such as words and nonsense syllables (Bower & Das, 1972).

Despite the sparsity of latency research in populations other than retarded, some significant results have been reported. Parsons and Chandler (1969) found that OR latencies of brain-damaged subjects were found to be significantly shorter. They discuss their results in terms of cortical-subcortical dynamic relationship. The reticular formation, a subcortical structure, is generally considered to be the site of the origin of electrodermal activity, which in turn is controlled by the cortex. Thus, habituation and nonspecific activity of the GSR is cortically controlled. Damage to the cortex leads to a greater number

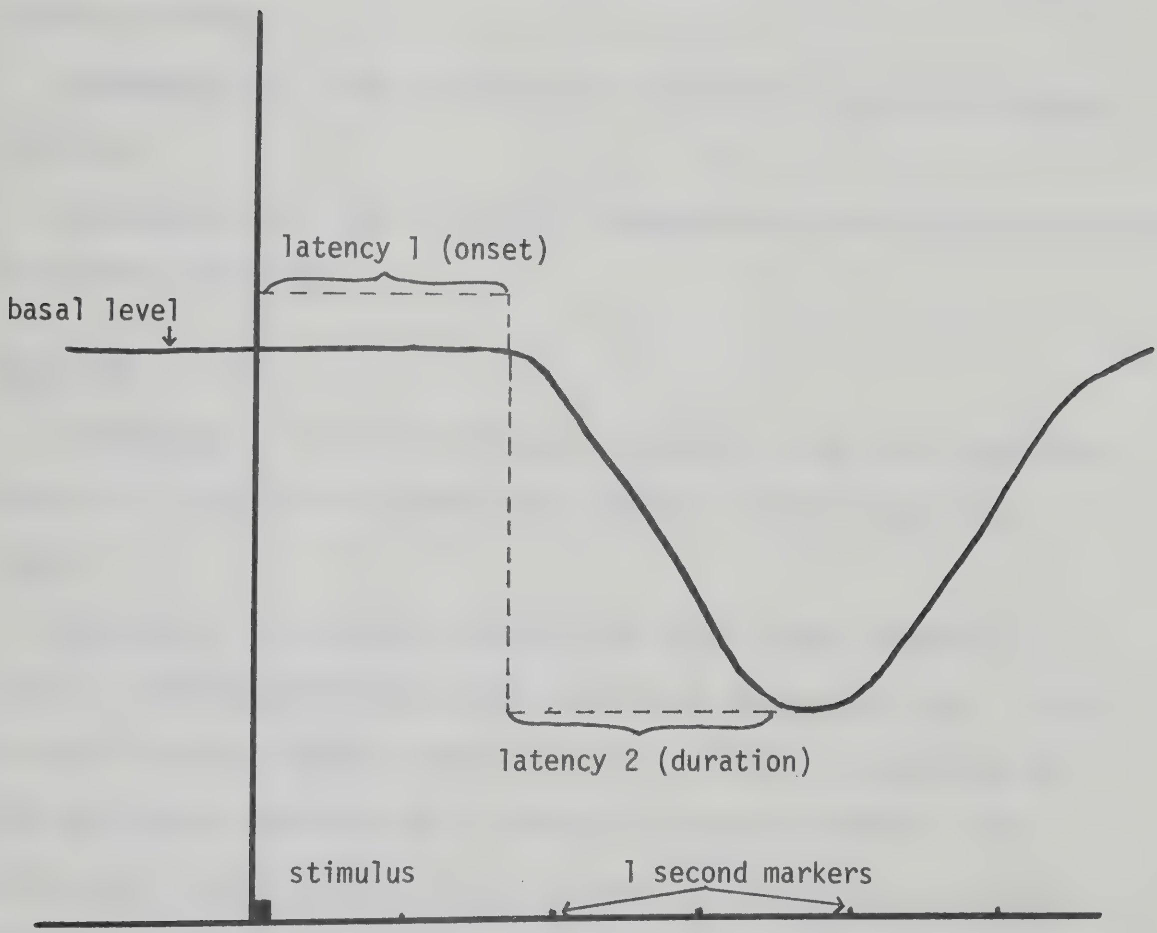


Fig. 8. Basal level, latency 1 and latency 2 of GSR

of nonspecific responses as well as shorter latencies of responses to stimulation.

Hypothesis 3.1. POA children will have shorter latencies than PNA and PUA children.

Hypothesis 3.2. PNA children will have shorter latencies than PUA children.

Hypothesis 3.3. PNA and control children will not differ significantly in response latencies.

Magnitude

Definition. The maximum change in (natural) logarithm conductance within 1-5 second period immediately following stimulus onset (see Figure 9).

Rationale. Magnitude of response has been studied intensely in mentally retarded populations, but results are once again mixed. In the two major reviews, Berkson (1961) and Karrer (1966) it is pointed out that differences might be due to stimulus intensity (Berkson, 1961), while Karrer (1966) feels that the IQ level of the mentally retarded might be a significant variable. Another reason may be that the terms magnitude and amplitude have been used interchangeably, when in actual fact they are two distinct measures (Lobb, 1968, 1970). Magnitude denotes an average amplitude (including zeros) of responses to several presentations of the stimulus. Amplitude, on the other hand, denotes the average amplitude responses but does not include zero responses (Bower & Das, 1972; Prokasy & Ebel, 1967). Magnitude is considered a more sensitive measure since amplitude is considerably affected by missing scores which tend to occur with habituation.

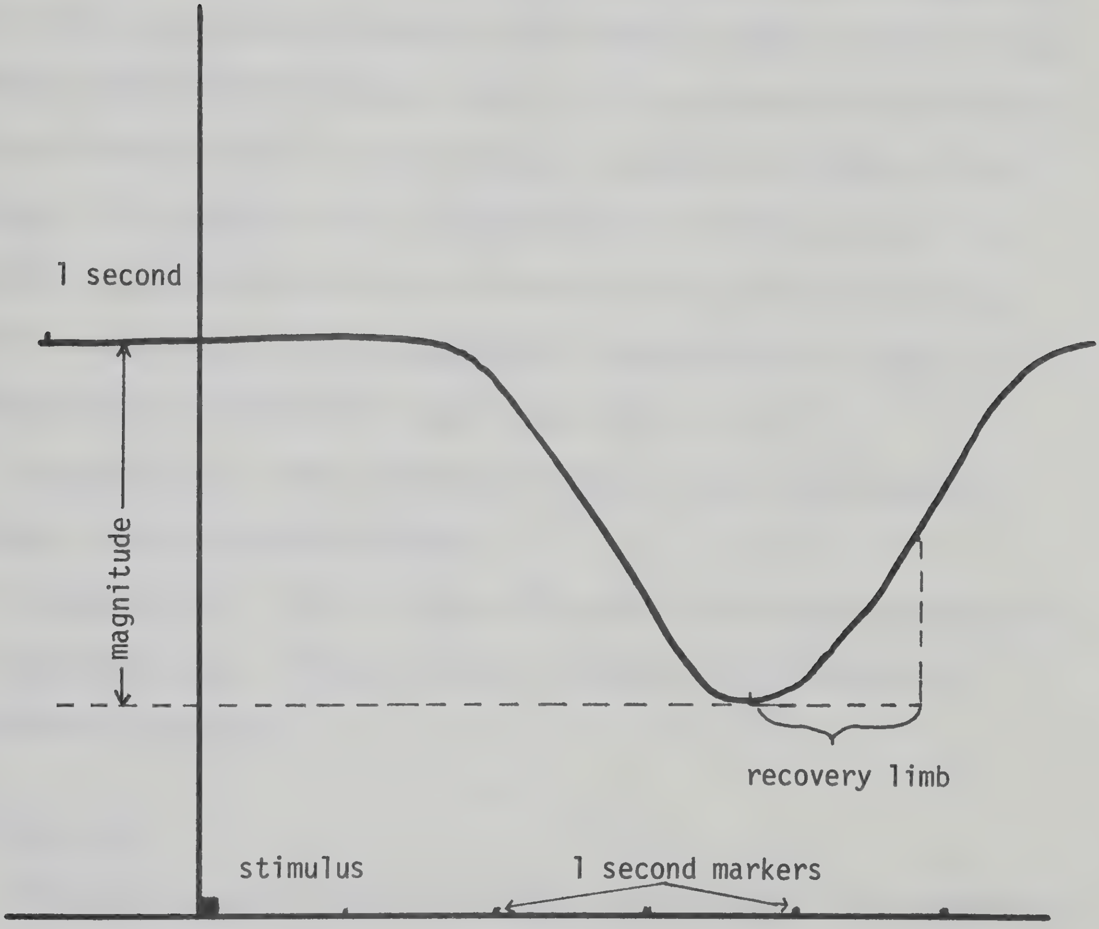


Fig. 9. Magnitude and recovery limb of GSR

[illegible]

Arousal level might be another significant variable that could account for these differences. Nebylitsyn (1973) reports that there is a positive correlation between habituation rate and initial magnitude, and since one of the hypotheses of this study is that habituation rate will be slower in POA children, then it is to be expected that magnitude of the initial response to the stimulus in the POA children will be greater: "In subjects with a predominance of excitation there is a tendency toward slow extinction of orienting GSRs and a fairly high initial magnitude, while subjects with a predominance of inhibition show the opposite tendencies (Nebylitsyn, 1973, p. 79)."

Hypothesis 4.1. POA children will show a larger magnitude of response than PNA and PUA children.

Hypothesis 4.2. PNA children will show a larger magnitude than PUA.

Hypothesis 4.3. PNA and control children will not differ in magnitude of response.

Recovery limb

Definition. This is the time taken from the peak of the response to reach the prestimulus level. However, Edelberg (1970) suggests that a reliable measure is the time taken to attain 50 per cent recovery (see Figure 8).

Rationale. Research on recovery rate is sparse. Raskin (1973) reports that the first consideration of recovery rate was made by Freeman and Katzoff (1942), who developed the term 'recovery quotient'. They considered it an index of the capacity of the CNS to recover from a disturbance and was usually applied to responses of long duration.

It has been used in research with several pathological conditions: mental retardation (Clausen & Karrer, 1969; Vogel, 1961), schizophrenia (Mednick & Schulsinger, 1968; Ax & Bamford, 1970).

Probably the work of Edelberg (1970, 1972a, 1972b) has revitalized interest in recovery rates. He considers the recovery rate as a useful index of psychological processes. In his studies he investigated speed of recovery as a function of different stimulus conditions (1970) and extended his results to cover task complexity and aversive stimulation (1972b). He also considered recovery rate and defensive behavior (1972a). He found that recovery rate was slower in subjects during a painful cold-pressor test and when warnings of an electric shock were given during a reaction time task. Furthermore, anxious individuals demonstrated slower recovery rates. Thus, his findings indicate that in a high arousal state a slower rate of recovery occurs.

Hypothesis 5.1. The POA children will have a longer rate of recovery than the PNA and PUA children.

Hypothesis 5.2. The PNA children will have a longer rate of recovery than the PUA children.

Hypothesis 5.3. The PNA children and controls will not differ in recovery rates.

Basal level

Definition. This is the average micromhos conductance level over 2 seconds prior to stimulus presentation.

Rationale. The use of basal conductance level as a measure of arousal has a long history, which goes back to the original work of Fere (Raskin, 1973). Woodworth and Schlosberg (1954) cite the works

of Waller and Wechsler, who showed that during the waking hours man undergoes various changes in basal level, ranging from low in the morning, high at midday and low in the evening. The results suggest that arousal level in individuals might well vary with changes in basal level. Arousal and basal levels have further been investigated by Duffy (1962) and Duffy and Lacey (1946), and the results indicated that basal level varies directly with the nature of the task with which the experimental subjects are confronted. Malmo (1958, 1959) also investigated arousal levels in terms of differences in basal level over a 24-hour period, and demonstrated a significant drop in basal level during sleep. More recent research has been conducted by Raskin, Kotses and Bever (1960), who investigated the OR and defensive reflex in 120 male college students, with basal level being considered a component of the OR. They found significant differences in basal level when the subjects were repeatedly presented with two blocks of stimuli. From the above research it appears that basal level is a good measure of arousal.

The basal level of the GSR has been used as a measure of arousal in several forms of psychopathology, including schizophrenia (Ax, Bamford, Beckett, Fretz & Gottlieb, 1970; Venables, 1964; Zahn, Rosenthal & Lawlor, 1969); mental retardation (Karrer, 1969); psychopathy (Hare, 1968). Parsons and Chandler (1969) examined basal level in brain-damaged patients and found a significantly higher basal level at rest than in normals. Boydstrun _et al_. (1968), in their study of children with minimal brain dysfunction, found no differences in basal level between the experimental group and control group, while Satterfield and Dawson (1971), contrary to their original hypothesis, found that hyperactive children

had lower basal levels than controls.

Basal level appears to be an indicant of arousal and in the light of the previous research mentioned, the following hypotheses are tendered:

Hypothesis 6.1. The POA children will have a higher prestimulus basal level than the PNA and PUA children.

Hypothesis 6.2. The PNA children will have a higher prestimulus basal level than the PUA children.

Hypothesis 6.3. The PNA children will not differ significantly from the control subjects on basal level.

Information Processing

The literature does not provide for a firm hypothesis regarding performance on simultaneous and successive tasks by children that are classified on levels of arousal. However, Strauss (Strauss & Lehtinen, 1947; Strauss & Kephart, 1955) suggests that the main difficulty of learning disabled children is that of spatial integration. In terms of successive and simultaneous synthesis, then, these children will have trouble with simultaneous synthesis. Furthermore, when one considers that the main characteristic of the 'Strauss' syndrome is that of hyperactivity, it is expected that the hyperactive child will perform poorly in simultaneous tasks compared to successive ones. Thus, the hyperkinetic child when compared with the normal control will perform significantly poorer on simultaneous tasks.

CHAPTER IV

METHOD

Sample

The learning disabled and the nonlearning disabled samples of elementary school children were selected from schools in the city of Edmonton. In selecting the groups, several criteria were enforced.

The first group of children were from special classes for children with learning disabilities. The criteria for placement into such classes is that children have an IQ of 85 and above and are at least two years behind their peers in academic achievement. The writer is aware of the heterogeneity that exists in this population and the exact nature of their academic difficulties was not considered an essential criterion for selection. Since the study was concerned mainly with hyperkinetic and hypokinetic behavior, children without any history of auditory and visual defects were selected. Furthermore, no child that was receiving medication for hyperkinesis such as Ritalin, or had undergone drug therapy within the three months prior to testing was selected. Additionally, only boys were selected since boys are more liable to be hyperkinetic than girls (Talkington & Hutton, 1973; Jenkins & Stable, 1971), and their ages were in the range of 8 to 12 years. The second sample, which was matched as to sex and approximate age, was drawn from children attending regular classes in Grades 3, 4 and 5.

Procedures, Instruments and Scoring

Sampling procedure

The selection of subjects from special and regular classrooms was based on the results of the child rating scale filled out by the teacher

of each child. Because of the limitations imposed by the school boards concerned, only 15 schools were involved.

The Child Rating Scale (CRS). Initially, two child rating scales were considered: (1) the scale developed by McConnell and Cromwell (1964) for measuring the activity level of retarded children, and (2) the scale developed by Davids (1971) for assessing hyperkinesis in children. Both scales are based on the earlier work of Laufer and Denhoff (1957) and Laufer, Denhoff and Solomon (1957). While both scales report good test-retest reliability, the Davids scale was chosen for the following reasons:

1. It combined the 10 items of the McConnell and Cromwell scale into six items.
2. Each item is rated on a 6 point scale and not a 5 point scale as it is on the McConnell and Cromwell scale.
3. A recent study by Burns and Lehman (1974) reported a high correlation of .922 between two raters who each rated the same 20 children five weeks apart.

The scale is found in Appendix A, with the only change being the addition of 'always getting into something' from the McConnell scale to the first characteristic, hyperactivity.

The CRS was distributed to teachers in special classes having students of the required age and IQ in the schools concerned. Each teacher was instructed to fill out the scale according to the instructions on the scale. One hundred and nineteen scales were returned from special classes. The raw scores from the scales were then factor analyzed to see whether or not the six items in the scale (hyperactivity, short attention span, variability, impulsiveness, irritability and explosiveness)

represent a unitary factor. If a strong factor emerges, factor scores could be derived from each child using the loading of each CRS measure as a weight to transform an individual's score. Thus, each subject would have a factor score for activity level. A distribution of the factor scores would then be drawn up, which could be divided into three groups of activity ranging from high through medium to low.

The result of the factor analysis is presented in Table 6. All the six items loaded on one factor and, based on this result, a factor score was obtained for each of the 119 children. Next, a distribution of the 119 scores was drawn with a mean of 0 and a standard deviation of 1. Following this, the children in the high activity group were defined as those whose scores were above +1 standard deviation,and the low activity group were those whose scores fell below -1 standard deviation. The extreme groups were identified as hyperkinetic and hypokinetic and the middle group as normokinetic. This distribution is represented in Figure 10.

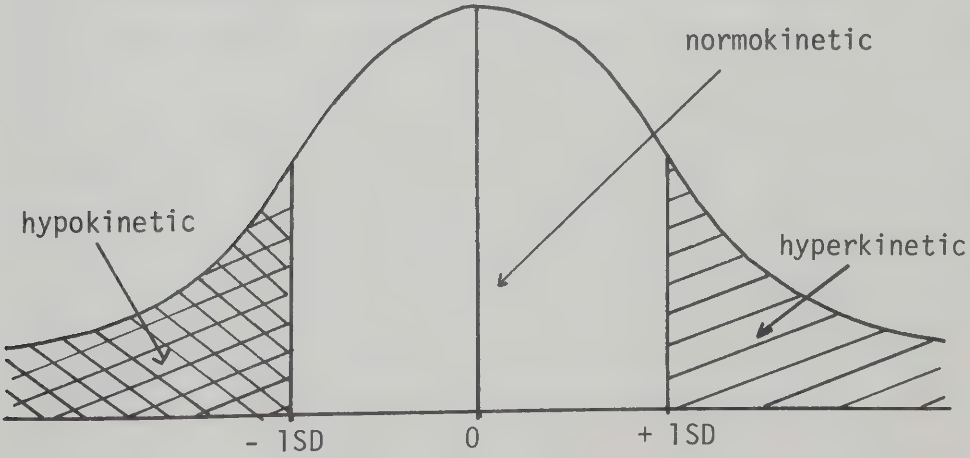


Fig. 10. Distribution of learning disabled children

Table 6

Principal Component with Unrotated Factor Matrix: Learning Disabled Group

Component	Communalities	I
Hyperactivity	606	778
Short attention span	371	609
Variability	765	875
Impulsivity	782	885
Irritability	655	810
Explosiveness	666	816

Sixty children were drawn from this distribution, 20 children from each segment. The selection of 60 was based on:

1. The requirement that there be a sufficiently large sample to perform a factor analysis. It is often preferred in factor analytic studies to have a larger group size than 60, but in studies that involve the use of individual tests, as was the case in this study, a smaller size must suffice.
2. The school boards concerned were reluctant to go beyond 60, since children in learning disabled classrooms are constantly in demand for research purposes.

The factor scores for the 60 experimental subjects are reported in Table 7 and for all the subjects in Appendix B.

The same procedure was followed for the selection of children from the regular grade. Scores for 60 children on the CRS were available. A factor analysis was conducted yielding the same result, i.e., one factor emerged (see Table 8). Factor scores were obtained and a distribution drawn with a mean of 0 and a standard deviation of 1. This sample consisted of 20 subjects which were drawn from the middle of the distribution, thus having factor scores clustering around the mean (see Table 9). As a result of the above procedures, 60 learning disabled and 20 children from regular grades were identified and used in the study. The mean age and mean IQ of the learning disabled children were 128.8 months and 98.8, respectively, while the regular grade children had a mean age of 113.8 months and a mean IQ of 112.2

In order that the children be brought to the University for autonomic and cognitive testing, parental permission was sought. Each

Table 7

Factor Scores for the Three Learning Disabled Groups

Hyperkinetic		Normokinetic		Hypokinetic	
Subject	Factor Score	Subject	Factor Score	Subject	Factor Score
1	1.153	1	-0.248	1	-1.123
2	1.412	2	0.177	2	-1.115
3	0.961	3	0.099	3	-1.109
4	1.397	4	0.184	4	-1.552
5	1.477	5	0.162	5	-1.552
6	1.160	6	0.028	6	-1.932
7	1.060	7	0.023	7	-1.093
8	1.905	8	0.064	8	-2.244
9	1.195	9	0.076	9	-1.093
10	1.021	10	0.290	10	-2.244
11	1.486	11	0.228	11	-1.494
12	1.625	12	-0.262	12	-1.175
13	0.948	13	-0.219	13	-1.961
14	1.170	14	-0.053	14	-1.552
15	1.186	15	0.137	15	-2.416
16	1.367	16	0.177	16	-1.964
17	1.335	17	0.177	17	-1.389
18	1.624	18	-0.072	18	-1.693
19	1.634	19	-0.234	19	-1.013
20	1.905	20	0.177	20	-1.566

Table 8

Principal Component with Unrotated Factor Matrix:
Normal Group

Component	Communalities	I
Hyperactivity	531	729
Short attention span	442	664
Variability	724	851
Impulsivity	750	866
Irritability	753	868
Explosiveness	715	845

Table 9

Factor Scores
of Child Rating Scale
for Normal Subjects

Subject	Factor Score
1	0.136
2	0.180
3	0.190
4	0.190
5	0.204
6	0.206
7	0.221
8	0.380
9	0.640
10	0.640
11	-0.013
12	-0.013
13	-0.272
14	-0.272
15	-0.309
16	-0.312
17	-0.351
18	-0.390
19	-0.400
20	-0.691

parent received a letter and form (see Appendix C) that required their signature which was returned to the investigator. Of the 60 learning disabled children, parental permission was refused for two children; consequently, 78 children were brought to the University for testing. Children were brought to the University in groups of three and, whenever possible, the three types of learning disabled children as identified by the CRS were brought together.

Autonomic and cognitive test procedures

All subjects were tested individually in both autonomic and cognitive tests. A set testing procedure was followed and is represented in Table 10. Which student underwent autonomic testing first, second and last was randomly determined. During the free time period on the schedule, the child was supervised by an adult and was provided with games, puzzles and books and mainly allowed to choose his own activities. Raven's Progressive Matrices, serial and free recall were considered the most challenging and most likely to produce anxiety in the child. Therefore, to avoid the effect of that anxiety on the autonomic measures, these tests were given after the autonomic testing.

Before the first autonomic testing session began, the children were taken into the laboratory where the testing procedure was outlined to them. The subjects were allowed to touch the polygraph and other pieces of equipment as they desired. This initial procedure in the laboratory would hopefully reduce anxiety in the subjects. After this the subjects were returned to the Centre's Library, and the investigator remained in the laboratory to await the first subject.

Table 10

Testing Procedure for Autonomic and Cognitive Testing

Time	Student 1	Student 2	Student 3
9:00-9:30	Autonomic testing	Serial and free recall Digit span Color naming	Serial and free recall Digit span Color naming
9:30-10:00	Raven's Progressive Matrices Figure Copying	Autonomic testing	Free time
10:00-10:30	Serial and free recall Digit span Color naming	Raven's Progressive Matrices Figure Copying	Autonomic testing
10:30-11:00	Free time	Free time	Raven's Progressive Matrices Figure Copying

Autonomic testing procedure. The laboratory consists of two adjoining rooms. The subject sits in a soundproof and electrically shielded room; the adjoining room containing the polygraph is used by the experimenter. A one-way mirror allows constant observation of the subject by the experimenter.

The polygraph which was used to record the GSR was a Hewlett-Packard 1500 model. To obtain readings of the GSR, three silver electrodes 0.5 inches in diameter were attached to the subject's right hand and arm; one attached to the palm, one to the back of the hand and the third, a ground, placed approximately 8 inches from the wrist on the arm. The flat electrodes were filled with Beckman paste and were securely attached by means of electrode adhesive collars.

The GSR recording session ran approximately 12 minutes for each subject and was divided into three periods and is schematically represented in Figure 11.

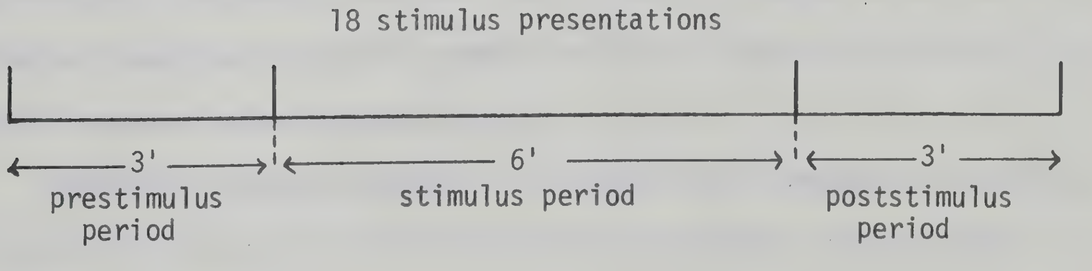


Fig. 11. Structure of GSR recording session

Period 1, the prestimulus period, was 3 minutes in length and the GSR recorded without any stimulus presentation. Period 2, the stimulus period, was 6 minutes in length and employed an habituation paradigm. A stimulus, the word 'boy' was presented auditorily every 20 seconds, a total of 18 times during the 6 minutes. Of these, the first four presentations were at an intensity of 80 dB and the 14 subsequent presentations had an intensity of 60 dB. This was done to assure a change in the GSR for at least the first four stimulus presentations. The auditory stimulus was supplied through a speaker on the wall, located above the subject's head. Period 3 was identical to period 1, i.e., no stimulus presentation. Period 3 was included in order that a comparison be made to period 1, to see what effects a period of stimulation might have on autonomic activity.

During the time that the subject was in the laboratory, he was seated comfortably in a padded leatherette chair and instructed not to do anything other than relax and sit as still as possible. He was further informed as to the nature of the situation, i.e., for the first 3 minutes no sound will be heard; then for the following 6 minutes a word will be repeated many times from the speaker on the wall behind him; and for the last 3 minutes again no sound at all.

Autonomic scoring procedure. The GSR and its components have been discussed in Chapter III; only the scoring procedure remains to be outlined.

Spontaneous fluctuations: This simply represents a frequency count of all nonstimulus bound GSRs. During the stimulus period a spontaneous GSR was considered only when a GSR appeared 5 seconds after the stimulus

had been presented, since a GSR occurring between 0 and 5 seconds after the onset of the stimulus is stimulus bound.

Habituation rate: During the period of stimulation, the number of trials to habituation were counted. The criteria for habituation was three consecutive nonresponses to stimuli.

Latencies: These were scored in tenths of seconds.

Recovery limb: This was measured in tenths of seconds.

Magnitude: The raw data were transformed into log conductance change scores.

Cognitive tasks

Measures of simultaneous synthesis

1. Raven's Progressive Matrices (RPM). The RPM was originally devised by Raven (1947) as a 'culture-fair' measure of reasoning ability and is a widely used test. It consists of three sets of problems, increasing in difficulty. The problems are presented visually as a sequence of patterns with one piece omitted, and the subject is required to select the correct piece from six possible choices to complete a stimulus pattern. The total score on the test is the total number of correct items, with a possible maximum of 36. A sample item from this test is found in Appendix D.

2. Figure Copying Test (FCT). This test was developed by Ilg and Ames (1964) as a measure of developmental readiness. The test does not involve a memory component since the subject is simply required to copy 10 geometrical forms increasing in level of difficulty. Each drawing is scored as 0, 1 or 2, depending on the degree of accuracy. Thus, the total score can range from 0 to 20. Copies of the 10 figures in the

test and guidelines for administering and scoring the test are in Appendix E.

Measures of successive synthesis

1. Serial recall. On this task the subjects are presented aurally with a series of 24 word sequences. The subject is required to verbally recall the sequence in the given serial order immediately following each presentation. Responses are scored only if they are in the correct serial position. The maximum possible score is 96. The list of words given in this test is found in Appendix F.

2. Free recall. This task is the same as the serial recall except that the correct serial position of the lists is not a scoring criterion. A point is given for every word recalled correctly. The maximum score possible is 96.

3. Digit span. This test was initially used by Molloy (1973) and Cummins (1973). The WISC subtest (Wechsler, 1949) digit span forward was used. The subject is read lists of digits of increasing length from three to nine digits. If the subject fails to recall all the digits of a certain list, he is given another list of equal length. The test is discontinued when the subject fails on both tests of a given series and is given the score equivalent to the highest number of digits correctly repeated. The maximum score is 9 points. A copy of the digit lists used is in Appendix G.

Measures of speed

1. Color naming. The speed tests originally used by Molloy (1973) were word reading and color naming, taken from the Stroop (1935) test. Because of the anticipated difficulty in reading by the experimental

subjects, the color naming test was used. Strips of red, green, yellow and blue are presented to a subject on a chart 28" x 30". The strips are printed in eight sets, with five strips in each set and the order of the sets randomized. The score on the test is the time obtained on a stopwatch for the subject to name the 40 colors. Appendix H has a list of the colors (since the colored strips cannot be presented) in the format in which they appear on the chart.

The reliability of the tests is not in doubt since the tests load the same way on all the factor analytic studies. While a study has yet to be conducted to demonstrate totally the validity of the construct of the factors, it would be difficult to label the factors without using concepts similar to simultaneous and successive synthesis.

CHAPTER V

RESULTS

The results are reported in four sections. Section 1 discusses the procedure for classifying the learning disabled children into three groups differing in physiological arousal levels, as indicated by a composite GSR score. In section 2, the results of the GSR scores and cognitive tasks are analyzed as they relate to the three groups of learning disabled children who are classified on the basis of physiological arousal levels. In section 3, the analysis of the scores which was obtained when the learning disabled children were grouped according to behavioral arousal measures is reported. Section 4 looks at the relationship between behavioral and physiological measures of arousal. The main implications of these results are discussed in the next chapter.

Procedure for Classification Based on Physiological Arousal

An initial examination of the GSR responses to the stimulus word 'boy' revealed that habituation occurred in many subjects after the first four stimulus presentations. Because of the presence of many 'no' responses to stimuli after the fourth presentation, it was decided to derive the arousal score from the GSR responses to the first four stimuli only. Of the 58 subjects brought to the University for autonomic testing, seven were rejected for the following reasons: responses of four subjects were unscoreable due to excessive movement; three subjects did not give a GSR. Thus, the GSR data of 51 subjects were available for analysis.

In order for the subjects to be divided into three groups, the same procedure was used as with the child rating scale, i.e., the data was first factor analyzed with the objective that, if a strong arousal factor emerged, then factor scores could be obtained for each child and a distribution drawn up. Because of the exploratory nature of the research, several factor analyses were undertaken to see which analysis would provide a strong factor which could be identified as arousal. The first factor analysis involved the four components of the GSR response, namely, latency 1, latency 2, magnitude, and recovery limb, along with the basal level prior to the first stimulus presentation. The factor matrix for this analysis is found in Table 11. One factor emerged, with all five components loading high. In a subsequent factor analysis, scores for spontaneous fluctuations and habituation rate were considered

Table 11

Principal Component with Unrotated Factor Matrix: Learning Disabled Group

Component	Communalities	I
Latency 1	0.321	0.567
Latency 2	0.533	0.730
Magnitude	0.584	-0.765
Recovery limb	0.693	0.833
Basal level	0.755	-0.869

both separately and simultaneously with the other five components. These analyses resulted in the emergence of two factors,when habituation rate or spontaneous fluctuations was included,and three factors when they were included together. The first factor analysis was used since one factor emerged, a condition which Kerlinger (1973) considers important since "a desideratum of scientific investigation is to have pure measures of variables (p. 662)".

From the factor matrix it is apparent that basal level and magnitude load highly but negatively (see Table 11). Taking basal level as the main indicant of physiological arousal, since it loaded the highest, the GSR of a POA individual, then, would be as follows: a high basal level, shorter latencies, larger magnitude and a quick recovery limb. For the PUA, the opposite would be true. This GSR response is depicted in Figure 12.

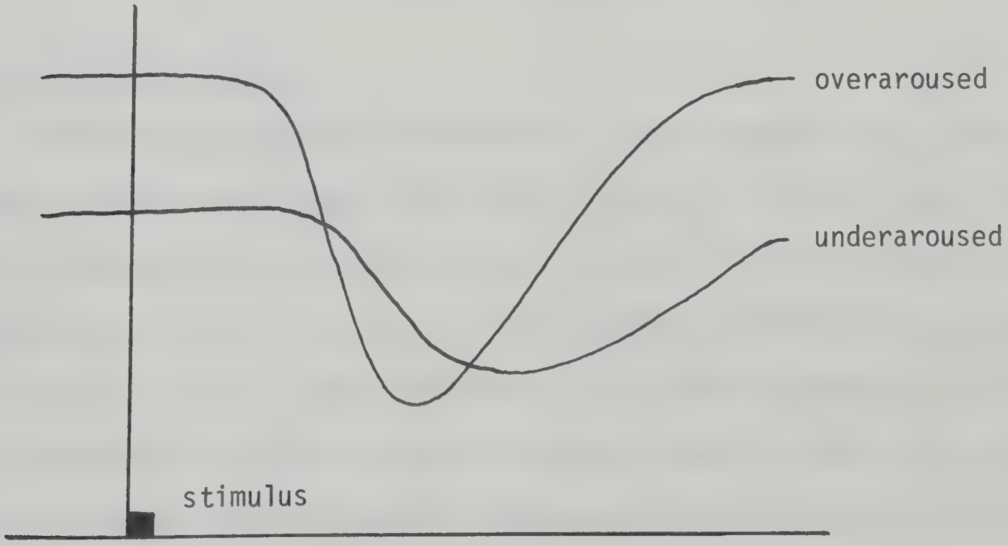


Fig. 12. Typical GSR response in physiologically overaroused and physiologically underaroused subjects

Based on the factor analysis, factor scores were obtained for each child by using the loading of the GSR measure as a weight to transform the individual child's score. With each child now having a GSR arousal score, a distribution was drawn up with a mean of 0 and a standard deviation of 1. The distribution was divided into three equal groups of physiological arousal: high, medium and low, with the POA group clustering around -1 standard deviation, while the PUA group clustered around +1 standard deviation. The PNA fell in the middle of the distribution. To avoid possible confusion that might arise from the fact that physiologically overaroused children have the largest negative numbers on the factor scores, the factor scores were transformed. Each GSR factor score was multiplied by (-1) and the constant 3 was added. The transformed factor scores are found in Table 12.

Classification Based on Physiological Arousal

Descriptive statistics

The means and standard deviations on each variable of the three PA groups and the normal group are given in Table 13. In order that the data be made more discernable, the data for each of the variables were changed into standard scores and are represented in Table 14 and plotted in Figures 13 and 14. With reference to the three PA groups, the pattern of GSR responses follow the expected pattern based on the result of the factor analysis, with the largest difference occurring between the groups on basal level and recovery limb. On the child rating scale variables, one is struck by the difference between the POA and the two other learning disabled groups, and the fact that the POA group score

Table 12

Transformed Factor Scores for the Three PA Groups

Subject	Physiologically Overaroused	Physiologically Aroused	Physiologically Underaroused
1	4.480	3.325	2.439
2	3.666	2.941	2.205
3	3.642	3.394	2.166
4	4.168	2.895	1.679
5	3.522	2.909	1.587
6	5.381	2.541	1.305
7	4.999	2.654	2.135
8	3.674	2.588	2.306
9	3.894	3.040	2.238
10	5.134	3.047	1.302
11	3.885	2.524	1.981
12	5.145	2.782	2.157
13	4.463	3.045	2.374
14	3.471	3.425	1.406
15	3.591	3.428	1.406
16	3.464	2.876	1.677
17	4.288	2.587	2.456

Table 13

Means and Standard Deviations on Three PA Groups and Control Group

Variable	POA		PNA		PUA		Control	
	M	SD	M	SD	M	SD	M	SD
Basal level	3.54	0.80	2.31	0.34	1.85	0.36	2.58	0.60
Latency 1	1.57	1.85	1.57	2.06	1.94	2.89	1.65	5.10
Latency 2	1.31	0.43	2.10	0.77	3.23	1.13	1.99	1.07
Magnitude	1.75	1.14	0.56	0.41	0.41	0.36	0.67	1.08
Recovery limb	2.88	3.28	6.81	3.32	11.62	2.38	5.80	5.32
Spontaneous fluctuations	14.00	8.79	14.47	11.79	7.70	4.16	16.26	15.15
Habituation rate	11.23	4.75	9.29	4.97	6.29	2.77	10.73	5.44
Hyperactivity	3.05	1.39	4.00	1.50	4.17	1.38	3.05	1.38
Short attention span	3.00	1.45	4.11	1.31	4.00	1.36	3.63	1.16
Variability	2.88	1.57	4.52	1.41	4.35	1.49	3.63	0.89
Impulsivity	2.88	1.66	4.23	1.39	4.11	1.50	3.47	1.02
Irritability	2.88	1.69	3.82	1.66	4.41	1.54	3.26	0.65
Explosiveness	2.76	1.54	3.64	1.39	3.82	1.81	2.78	0.78

Table 13 (continued)

Means and Standard Deviations on Three PA Groups and Control Group

Variable	POA		PNA		PUA		Control	
	M	SD	M	SD	M	SD	M	SD
Raven's Progressive Matrices	27.29	4.36	27.64	3.82	26.05	4.29	29.21	3.88
Figure Copying	12.11	1.99	12.35	3.04	12.17	2.81	14.36	2.36
Digit span	5.41	1.06	5.00	1.06	5.05	1.08	5.52	0.96
Free recall	85.17	7.08	83.35	11.01	81.00	11.12	90.89	3.54
Serial recall	76.35	14.46	70.58	20.84	68.35	20.95	86.21	8.64
Color naming	38.17	12.29	33.58	7.21	38.29	6.65	31.10	5.67

Table 14

Standard Score Means for Three PA Groups and Control Group

Variable	POA	PNA	PUA	Control
Latency 1	-0.31	-0.30	0.71	-0.08
Latency 2	-0.75	-0.04	0.95	-0.14
Magnitude	0.93	-0.29	-0.44	-0.17
Recovery limb	-0.79	0.01	1.00	-0.27
Spontaneous fluctuation	0.07	0.11	-0.49	0.27
Habituation rate	0.36	-0.02	-0.63	0.26
Basal level	1.17	-0.31	-0.87	0.01
Hyperactivity	-0.36	0.32	0.44	-0.36
Short attention span	-0.50	0.31	0.22	-0.03
Variability	-0.64	0.46	0.34	-0.14
Impulsivity	-0.61	0.35	0.48	-0.19
Irritability	-0.46	0.15	0.54	-0.21
Explosiveness	-0.29	0.25	0.36	-0.28
Raven's Progressive Matrices	-0.07	0.01	-0.37	0.38
Figure Copying	-0.25	-0.16	-0.23	0.58
Digit span	0.14	-0.24	-0.18	0.25
Free recall	-0.01	-0.20	-0.46	0.60
Serial recall	0.03	-0.28	-0.40	0.58
Color naming	0.34	-0.18	0.35	-0.46

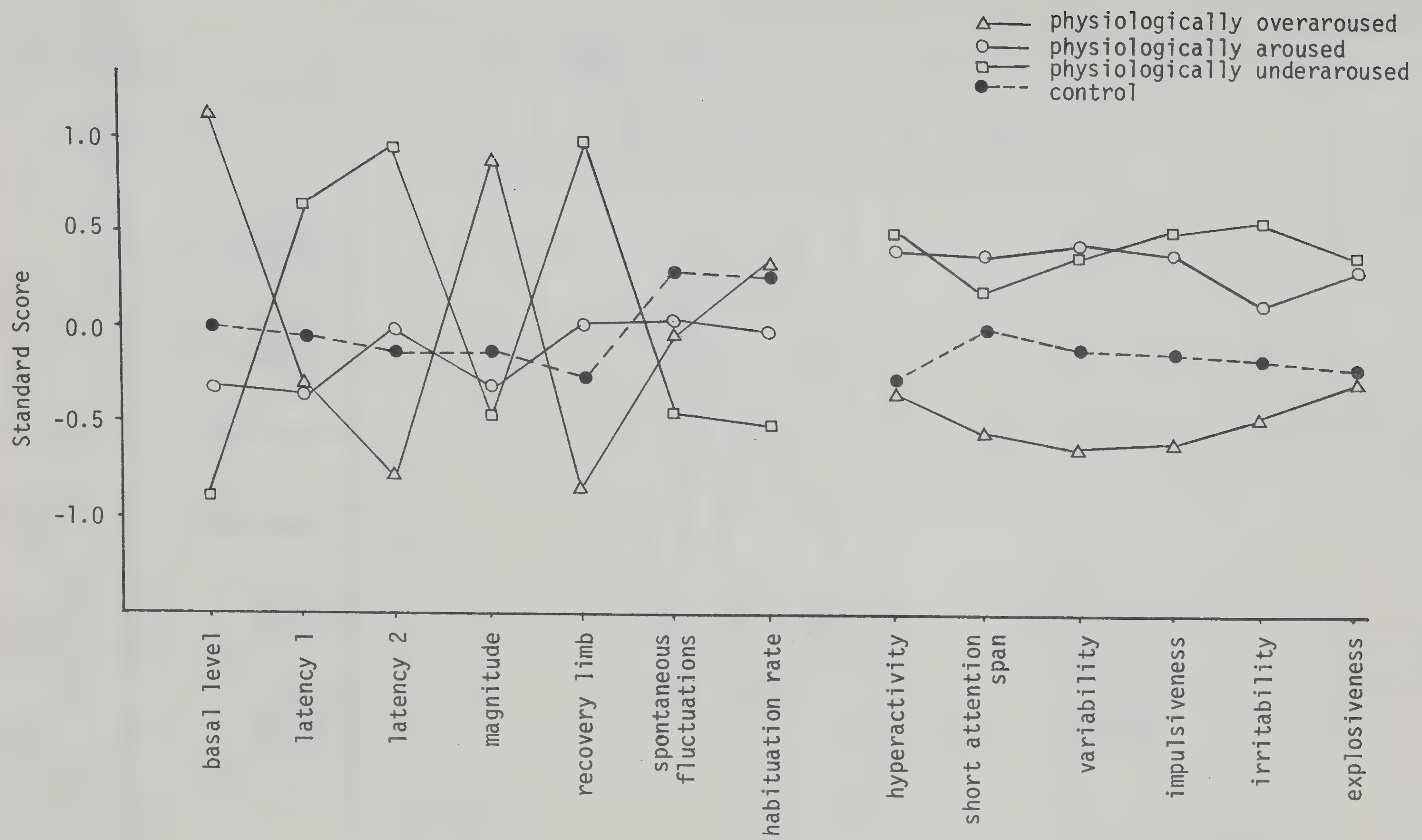


Fig. 13. Standard score means of GSR and CRS variables of physiologically aroused groups and control group

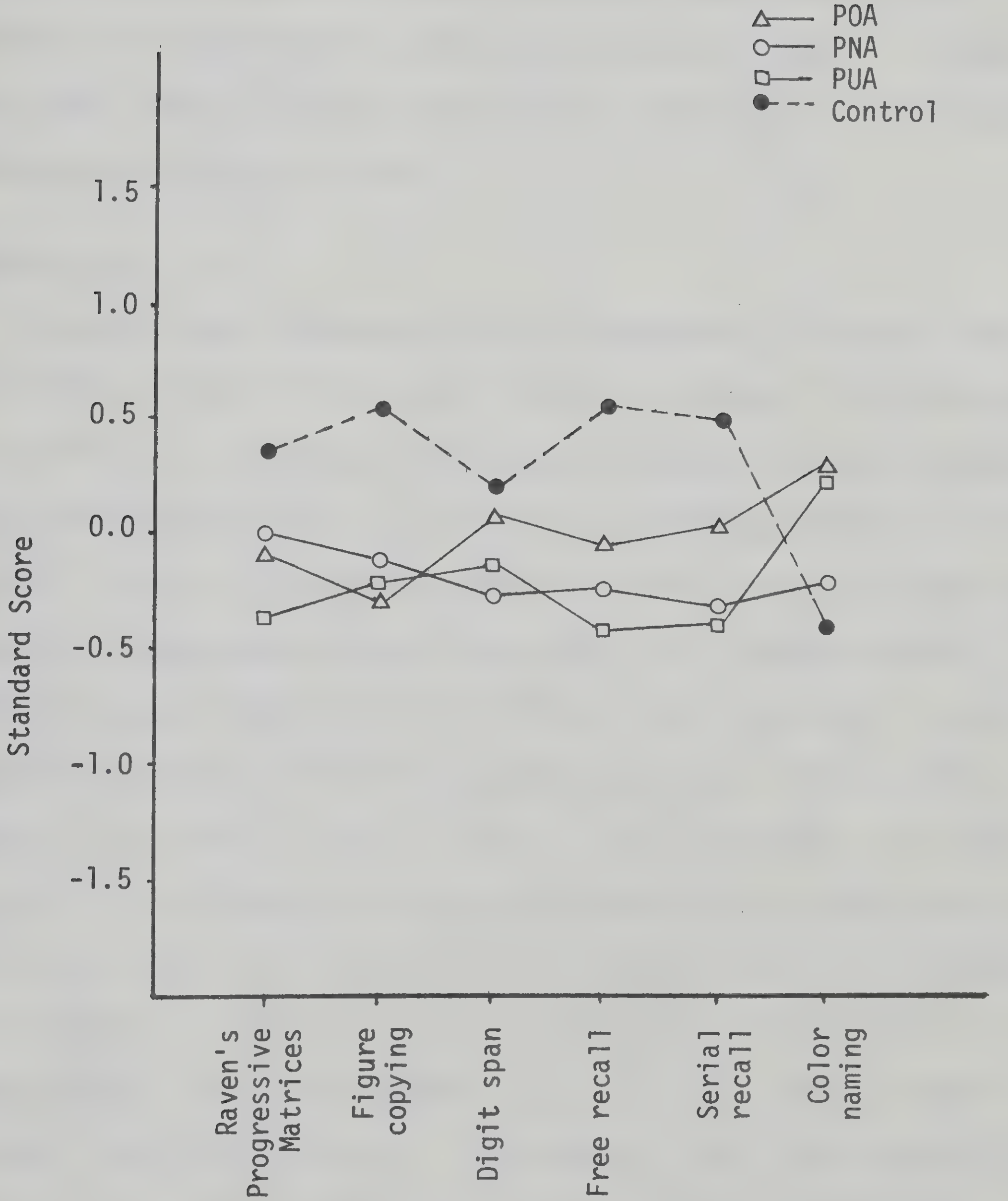


Fig. 14. Standard score means of three GSR groups and control group on cognitive tasks

consistently low on the CRS variables. In relation to the cognitive variables, all learning disabled groups appear similar. The control group follows a similar pattern to the PNA group for both GSR and CRS variables, but on cognitive tasks the control group appears quite different on Figure Copying, free recall and serial recall. In order that these trends be further investigated, a detailed look at the GSR and cognitive data now follows.

GSR analysis

From the factor loadings of the GSR components, a distinct shape of the GSR for each of the three PA groups is apparent. The POA response is typified by a high basal level, short latencies, a large magnitude and a quick recovery limb. Even though the response patterns are quite distinct, do they significantly differ from each other? To answer this question a three-group one-way fixed-effects multivariate analysis (MANOVA) was performed on the five GSR variables, the result of which indicated significant differences between the groups, with a Wilk's Lambda of 0.13 and $\underline{F}(10, 88) = 15.44$ ($p < 0.0$). In order to see the nature of the differences, a discriminant analysis was conducted; the vectors of weights for the discriminant functions of the five variables are presented in Table 15. Vector 1 produced the highest level of significance, having a chi-square = 87.17 ($p < 0.0$), thus providing the best discriminant analysis. From vector 1, the largest weight by far is derived from the basal level, with all other weights being considerably less. The finding that basal level discriminates best between the three groups is confirmation of the suggested difference founc in Figure 12; it also coincides with the results of the factor analysis.

Table 15

Scaled Discriminant Function Weights
for Five GSR Variables

Variable	Vector 1	Vector 2
Latency 1	2.1479	5.2928
Latency 2	2.1117	1.4961
Magnitude	0.9715	4.7878
Recovery limb	1.2805	-0.9928
Basal level	-3.6933	0.1114

In addition to finding a significant F between the groups using a MANOVA, more information was sought concerning group differences by multiple comparison of means (Scheffé's test). The results of the test are found in Table 16. Significant differences are found on all variables. On latency 1, the PUA group had a significantly longer latency than both the POA and PNA groups. On magnitude, the POA had a significantly longer magnitude than both the PNA and PUA groups. However, on basal level, recovery limb and latency 2, significant differences were found among all groups.

Spontaneous fluctuations and habituation rate. The three physiologically aroused groups were compared on the two other GSR variables, spontaneous fluctuations and habituation rate. A one-way analysis of variance (ANOVA) followed by a Scheffé test were conducted on each variable. No significant differences were found between the groups on spontaneous fluctuations. On habituation rate, an overall

Table 16

ANOVA and Scheffé Test for Three PA Groups on Five GSR Variables

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Latency 1

ANOVA

Source	SS	MS	DF	F	P
Groups	150.2734	75.14	2	14.03	0.000016
Error	257.1210	5.36	48		

Probability matrix for Scheffe multiple comparison of means

	1	2	3
1. POA	1.0000	0.9982	0.0001
2. PNA	0.9982	1.0000	0.0002
3. PUA	0.0001	0.0002	1.0000

Latency 2

ANOVA

Source	SS	MS	DF	F	P
Groups	3155.4180	1577.71	2	22.71	0.000000
Error	3334.2070	69.46	48		

Probability matrix for Scheffe multiple comparison of means

	1	2	3
1. POA	1.0000	0.0273	0.0000
2. PNA	0.0273	1.0000	0.0013
3. PUA	0.0000	0.0013	1.0000

Magnitude

ANOVA

Source	SS	MS	DF	F	P
Groups	18.4590	9.23	2	17.19	0.000002
Error	25.7713	0.54	48		

Table 16 (continued)

ANOVA and Scheffé Test for Three PA Groups on Five GSR Variables

Probability matrix for Scheffe multiple comparison of means

		1	2	3
1.	POA	1.0000	0.0001	0.0000
2.	PNA	0.0001	1.0000	0.8359
3.	PUA	0.0000	0.8359	1.0000

Recovery limb

ANOVA

Source	SS	MS	DF	F	P
Groups	65128.9380	32564.47	2	35.41	0.000000
Error	44141.5000	919.61	48		

Probability matrix for Scheffe multiple comparison of means

		1	2	3
1.	POA	1.0000	0.0019	0.0000
2.	PNA	0.0019	1.0000	0.0001
3.	PUA	0.0000	0.0001	1.0000

Basal level

ANOVA

Source	SS	MS	DF	F	P
Groups	26.0747	13.04	2	43.31	0.000000
Error	14.4489	0.30	48		

Probability matrix for Scheffe multiple comparison of means

		1	2	3
1.	POA	1.0000	0.0000	0.0000
2.	PNA	0.0000	1.0000	0.0578
3.	PUA	0.0000	0.0578	1.0000

significant difference was found between the groups, $F(2, 48) = 5.75$, $p < 0.005$, but on the Scheffé test significance was found only between the two extremes, the POA and PUA ($p < 0.006$).

To investigate differences that might exist between the three PA groups and the control group, an ANOVA followed by a Scheffe test were conducted on all seven GSR variables, complete details of which are given in Appendix I. No significant differences were found between the PA groups and the control group on latency 1 and spontaneous fluctuations. Significant differences produced by the Scheffé test were obtained on the following variables as follows: the control group differed from the POA group by having a smaller magnitude ($p < 0.004$) and a lower basal level ($p < 0.0001$); the control group differed from the PUA group by having a faster latency 2 ($p < 0.001$), a quicker recovery limb ($p < 0.0004$), a slower habituation rate ($p < 0.04$) and a higher basal level ($p < 0.003$).

Basal level: A supplementary analysis. A supplementary analysis of scores on basal level was decided upon because the basal level was continually found to be the best discriminator.

reading over the 2 seconds prior to the first stimulus presentation. Four basal level readings were taken for the 1 minute period immediately prior to the first stimulus presentation. The readings were at intervals of 20 seconds. Seventeen other readings were taken during the period of stimulation. The reading here was the average over 2 seconds prior to each stimulus presentation. The readings for the three groups are plotted in Figure 15. Although slight fluctuations appear in the basal

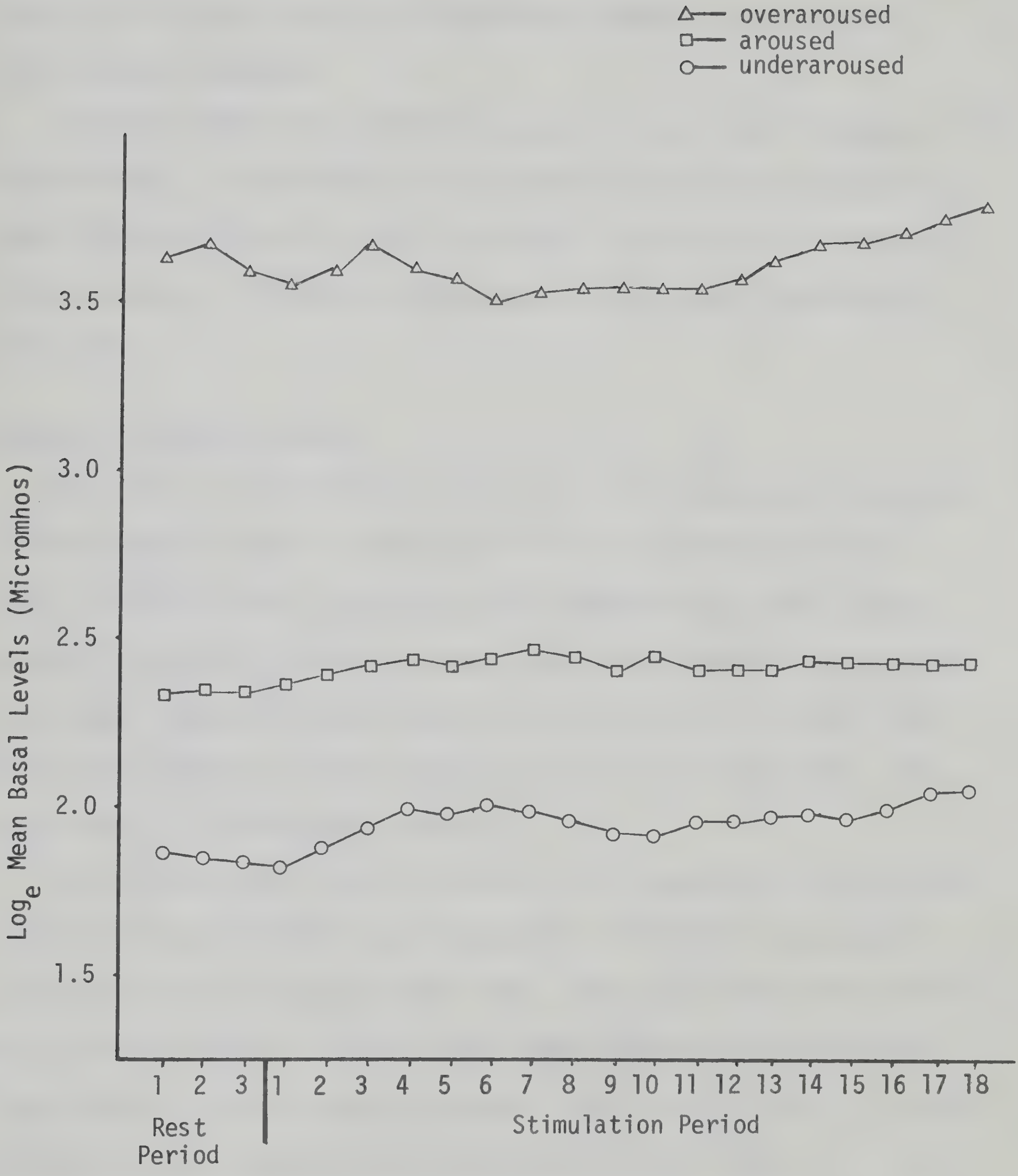

Fig. 15. Basal level of physiologically aroused groups

levels of the three groups, the differences between the groups are consistently maintained.

A two-way ANOVA with repeated measures on one factor (3 groups x 17) was performed. A significant 'A' main effect was obtained between the groups with an $\underline{F}(2, 48) = 36.80$ ($p < 0.001$). No interaction between the groups occurred. The basal level appears to be a good discriminator across time.

Analysis of cognitive data

None of the investigations to date into simultaneous and successive syntheses have included a population of learning disabled children. Thus, as a first step, the scores on the cognitive tests were factor analyzed to see what factors emerged. The factor analysis employed was a principal components with varimax rotation as had been usually done in previous analyses of the simultaneous and successive battery. The factor matrix is presented in Table 17.

Three factors were clearly obtained and represent the three factors identified by Das (1973b),i.e., successive, simultaneous and speed. Factor I has high loadings on digit span, free recall and serial recall--the successive factor. Factor II has strong loadings on Raven's and Figure Copying, clearly the simultaneous factor; while factor III loads high only on color naming, thus providing the speed factor.

As stated earlier, an objective of this study was to see if the different levels of arousal are related to information integration. To investigate this, a three-group one-way fixed-effects MANOVA was performed on both raw cognitive scores and cognitive factor scores. The resulting $\underline{F}$

Table 17

Principal Components with Varimax Rotation of Cognitive Test Scores

Test	Communalities	I	II	III
Raven's Progressive Matrices	0.703	0.227	0.775	0.227
Figure Copying	0.792	-0.058	0.866	-0.197
Digit span	0.746	0.845	0.100	0.147
Free recall	0.904	0.916	-0.002	-0.254
Serial recall	0.910	0.922	0.113	-0.216
Color naming	0.933	-0.158	-0.000	0.953
Component variance	4.988	2.484	1.373	1.131

was not significant either with the raw scores ($p < 0.07$) or factor scores ($p < 0.58$). Next, a MANOVA was carried out on the three groups of learning disabled children and the control group. While significance was not found, the result approached significance ($p < 0.06$) and because of this, an exploratory univariate analysis and a Scheffe test were carried out to see the general trend in differences. Significance was found on two of the six variables: free recall with an $\underline{F}(3, 66) = 4.33$, $p < 0.007$, and serial recall with an $\underline{F}(3, 66) = 4.09$, $p < 0.01$. While an overall significance was found on the two variables, the Scheffé test was significant between two groups only, the control and PUA, with the PUA performing significantly poorer on the tasks. The level of significance for free recall was $p < 0.01$, and serial recall $p < 0.02$.

In summary, then, cognitive differences between the three groups were not found, but when control group and learning disabled group comparisons were made, univariate significance was seen between the control and PUA groups on free recall and serial recall.

Classification Based on Behavioral Arousal

What follows is the analysis of the data of the learning disabled children when they are grouped into hyperkinetic, hypokinetic and normokinetic, based on the child rating scale factor scores. This procedure has been discussed in Chapter IV.

Descriptive statistics

The means and standard deviations for the 19 variables of the three learning disabled groups and the normal group are given in Table 18. The data for each of the variables were transformed into standard scores to

Table 18

Means and Standard Deviations on Three CRS Groups and Control Group

Variable	POA		PNA		PUA		Control	
	M	SD	M	SD	M	SD	M	SD
Latency 1	1.79	0.19	1.66	0.34	1.63	0.29	1.65	0.51
Latency 2	2.80	1.45	1.94	0.95	1.89	0.65	1.99	1.07
Magnitude	0.58	0.47	0.92	0.96	1.24	1.18	0.67	1.08
Recovery limb	9.32	3.63	6.08	4.91	5.90	4.79	5.80	5.32
Spontaneous fluctuations	9.82	5.00	11.83	10.74	14.68	10.53	16.26	15.50
Habituation rate	7.17	4.14	9.61	4.75	10.06	4.83	10.73	5.44
Basal level	2.24	0.53	2.56	0.97	2.91	1.03	2.58	0.60
Hyperactivity	5.11	0.78	4.11	0.47	1.87	0.61	3.05	1.38
Short attention span	4.58	1.12	3.88	1.27	2.56	1.20	3.63	1.16
Variability	5.58	0.61	4.11	0.67	1.93	0.85	3.63	0.89
Impulsivity	5.41	0.61	3.94	0.72	2.06	0.57	3.47	1.02
Irritability	5.52	0.71	3.66	1.08	1.81	0.65	3.26	0.65
Explosiveness	5.23	1.20	3.33	1.13	1.56	0.51	2.78	0.78

Table 18 (continued)

Means and Standard Deviations of Three CRS Groups and Normal Group

Variable	POA		PNA		PUA		Control	
	M	SD	M	SD	M	SD	M	SD
Raven's Progressive Matrices	26.58	3.89	26.00	4.17	28.56	4.16	29.21	3.88
Figure Copying	12.05	2.70	11.94	2.81	12.68	2.33	14.36	2.36
Digit span	5.11	1.21	4.88	0.67	5.50	1.21	5.52	0.96
Free recall	82.05	11.11	82.27	9.22	85.37	1.21	90.89	3.54
Serial recall	67.17	22.82	70.55	16.15	78.00	16.56	86.21	8.64
Color naming	36.82	7.76	38.27	12.69	34.75	5.14	31.10	5.67

facilitate interpretation. The transformed scores are represented in Table 19 and are plotted in Figures 16 and 17.

The pattern of responses for the three learning disabled groups will be discussed first. If there are differences between the groups on the CRS variables, the hyperkinetic group will be the group that differs, particularly on latency 2 and recovery limb. The hypokinetic and normokinetic have very similar response patterns on all GSR variables. The most striking feature of the GSR response patterns of the hyperkinetic group is that they are exactly opposite to the POA group. The child rating scale variables follow the expected pattern, based on the result of the factor analysis, with large differences on all variables and with short attention span being the least sensitive discriminator. On the cognitive tasks, the hypokinetic group appears considerably higher than the hyper- and normokinetic groups on all tasks except color naming.

When the normal group is compared with the three groups, the pattern of responses on the GSR variables closely follows that of the normokinetic and hypokinetic, and the normokinetic on child rating scale scores. The only exception here would be on hyperactivity. On cognitive tasks, there appears to be some difference in Figure Copying, free recall and serial recall.

To investigate these trends further, a more detailed analysis of the data now follows.

Child Rating Scale analysis

A three-group one-way fixed-effects MANOVA was conducted on the learning disabled groups. A significant difference was found between the groups, with a Wilk's Lambda = 0.04 and $\underline{F}(12, 86) = 26.31$ ($p < 0.0$).

Table 19

Standard Score Means for Three CRS Groups and Normal Group

Variable	Hyperkinetic	Normokinetic	Hypokinetic	Normal
Latency 1	0.29	-0.05	-0.15	-0.08
Latency 2	0.58	-0.19	-0.23	-0.14
Magnitude	-0.26	0.07	0.40	-0.17
Recovery limb	0.52	-0.13	-0.17	-0.19
Spontaneous fluctuation	-0.30	-0.12	0.13	0.27
Habituation rate	-0.45	0.03	0.12	0.26
Basal level	-0.39	-0.00	0.41	0.01
Hyperactivity	1.13	0.40	-1.21	-0.36
Short attention span	0.65	0.14	-0.82	-0.03
Variability	1.17	0.18	-1.28	-0.14
Impulsivity	1.20	0.14	-1.20	-0.19
Irritability	1.28	0.05	-1.16	-0.21
Variability	1.24	0.05	-1.04	-0.28
Raven's Progressive Matrices	-0.24	-0.38	0.23	0.38
Figure Copying	-0.27	-0.31	-0.04	0.58
Digit span	-0.13	-0.35	0.23	0.25
Free recall	-0.34	-0.32	0.01	0.60
Serial recall	-0.47	-0.28	0.12	0.58
Color naming	0.18	0.35	-0.04	-0.46

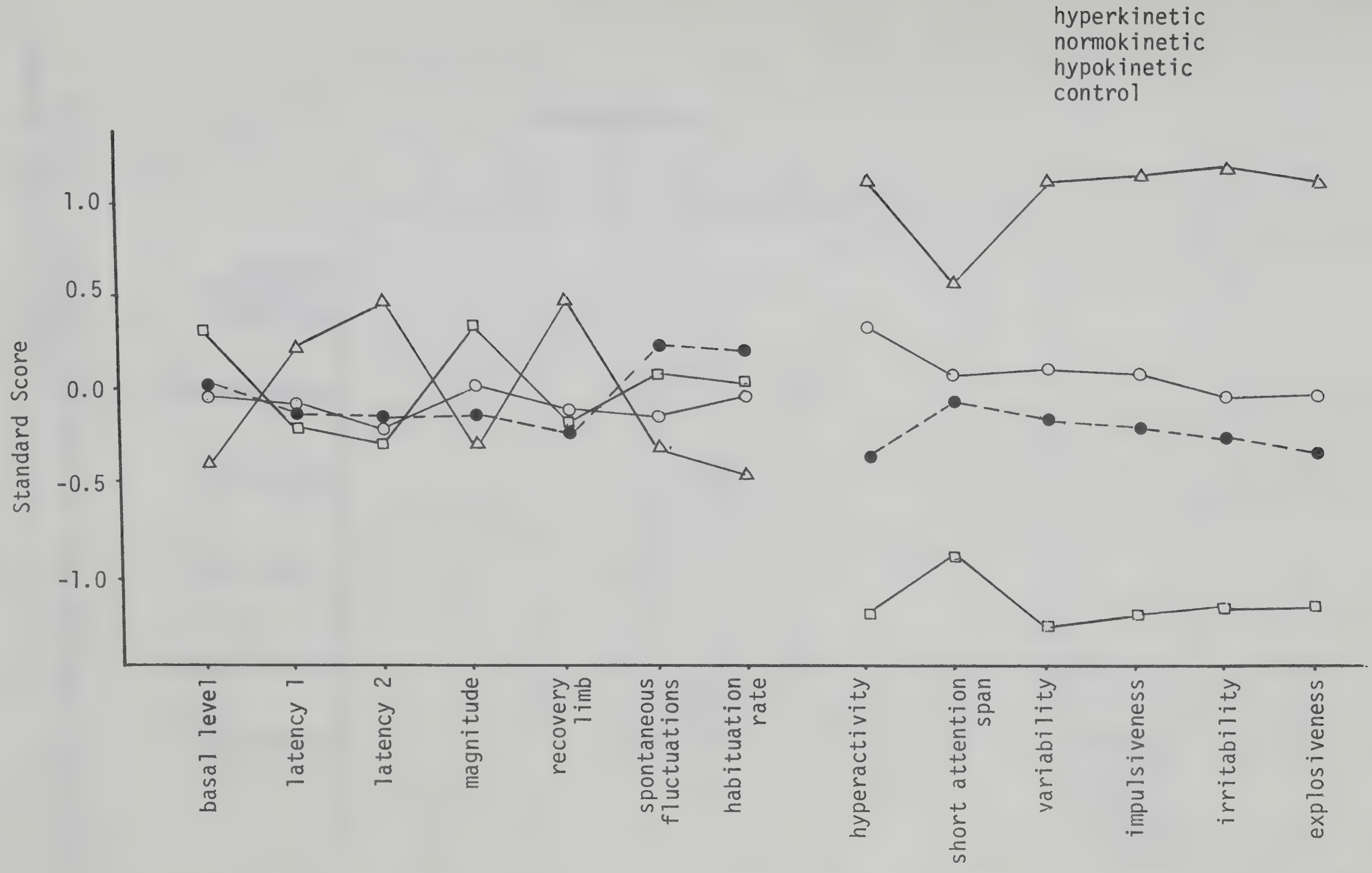

Fig. 16. Standard score means of GSR and CRS variables of behaviorally aroused and control groups

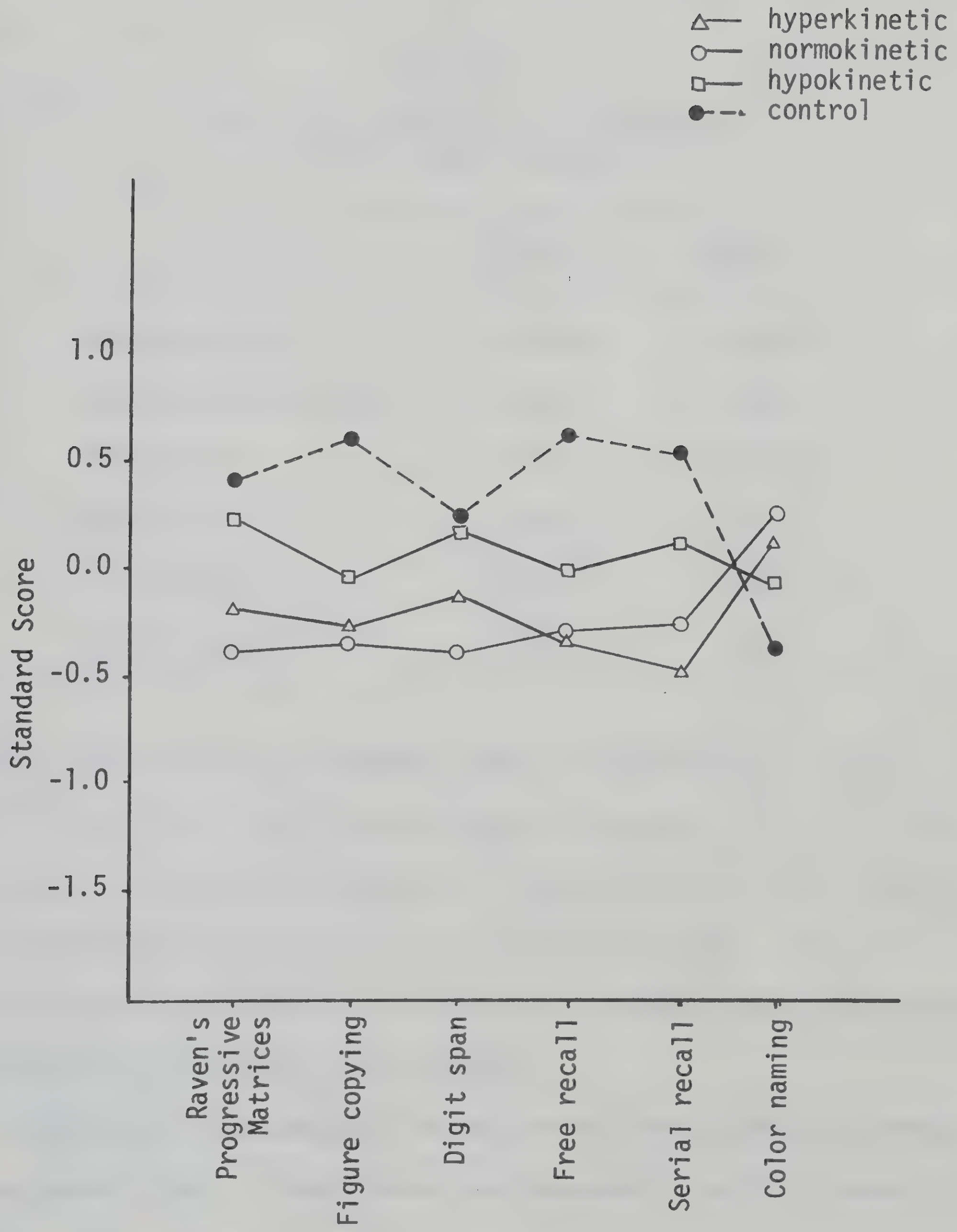

Fig. 17. Standard score means of three CRS groups and control group on cognitive tasks

To determine the nature of the differences between the groups on the CRS variables, a discriminant function was performed. The vectors of weights for the discriminant functions are presented in Table 20. Only vector 1 produced a statistically acceptable level of significance, having a chi-square = 134.12 ($p < 0.0$); vector 2 had a chi-square = 5.51 ($p < 0.35$). From vector 1 all positive weights are large except for short attention span, which therefore is the least discriminative index. The five other variables are fairly equal in discriminative strength, with explosiveness and impulsivity the better discriminators.

Table 20

Scaled Discriminant Function Weights
for Six CRS Variables

Variable	Vector 1	Vector 2
Hyperactivity	2.1208	3.8259
Short attention span	0.7727	-1.3952
Variability	2.1051	0.3732
Impulsivity	2.4863	-1.2213
Irritability	2.2239	-1.7526
Explosiveness	2.5052	-1.4788

A MANOVA was also conducted on the three learning disabled groups and the normal group. Significance was found with a Wilk's Lambda = 0.07 and _F_(18, 173) = 14.49 ($p < 0.0$).

Significant differences have been found between the three learning disabled groups, and between these groups and the normal group. However,

in order to investigate the nature of the differences between the groups on the six CRS variables, a Scheffé test was carried out. The results are found in Table 21. On hyperactivity, significant differences exist between all four groups, while on short attention span, significance was found only between normokinetic and hypokinetic groups and between hyperkinetic and hypokinetic groups. For the remaining four variables, variability, impulsivity, irritability and explosiveness, the same pattern of differences between the groups occurs. The only nonsignificant comparison on these four variables was between the normokinetic and normal groups. These findings clearly support the visual trends in Figure 15.

Analysis of cognitive data

A three-group one-way fixed-effects MANOVA was performed on both raw cognitive scores and cognitive factor scores. No significance was found with the raw scores ($p < 0.52$) or cognitive factor scores ($p < 0.62$). A further MANOVA was conducted on the three learning disabled groups and the control group of children. The results of this MANOVA indicated significant differences between the groups with a Wilk's Lambda of 0.62 and $\underline{F}(18, 173) = 1.7$ ($p < 0.03$). In order to see where the differences lie between the normal group and the learning disabled groups, a univariate analysis and Scheffé test were carried out. No significant differences were found between the groups on Raven's Progressive Matrices, digit span or color naming. Significant differences were found on Figure Copying, free recall and serial recall, details of which are found in Table 22. While an overall significance was found on these three tests, the Scheffé test confirmed that the following differences were significant:

Table 21

ANOVA and Scheffé Test for Three CRS Groups
and Control Group on CRS Variables

Hyperactivity

ANOVA

Source	SS	MS	DF	F	P
Groups	97.0312	32.34	3	62.34	0.000001
Error	34.2402	0.54	66		

Probability matrix for Scheffé multiple comparison of means

	1	2	3	4
1. Normokinetic	1.0000	0.0016	0.0000	0.0005
2. Hyperkinetic	0.0016	1.0000	0.0000	0.0000
3. Hypokinetic	0.0000	0.0000	1.0000	0.0002
4. Normal-Control	0.0005	0.0000	0.0002	1.0000

Short attention span

ANOVA

Source	SS	MS	DF	F	P
Groups	34.8317	11.61	3	8.13	0.000100
Error	94.2541	1.43	66		

Probability matrix for Scheffé multiple comparison of means

	1	2	3	4
1. Normkinetic	1.0000	0.3994	0.0207	0.9339
2. Hyperkinetic	0.3994	1.0000	0.0001	0.1354
3. Hypokinetic	0.0207	0.0001	1.0000	0.0836
4. Normal-Control	0.0339	0.1354	0.0836	1.0000

Table 21 (continued)

ANOVA and Scheffé Test for Three CRS Groups and Control Group on CRS Variables

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Variability

ANOVA

Source	SS	MS	DF	F	P
Groups	112.0173	37.34	3	62.78	0.000001
Error	39.2541	0.59	66		

Probability matrix for Scheffé
multiple comparison of means

	1	2	3	4
1. Normkinetic	1.0000	0.0000	0.0000	0.3199
2. Hyperkinetic	0.0000	1.0000	0.0000	0.0000
3. Hypokinetic	0.0000	0.0000	1.0000	0.0000
4. Normal-Control	0.3199	0.0000	0.0000	1.0000

Impulsivity

ANOVA

Source	SS	MS	DF	F	P
Groups	94.6347	31.54	3	53.75	0.000001
Error	38.7368	0.59	66		

Probability matrix for Scheffé
multiple comparison of means

1. Normkinetic	1.0000	0.0000	0.0000	0.3304
2. Hyperkinetic	0.0000	1.0000	0.0000	0.0000
3. Hypokinetic	0.0000	0.0000	1.0000	0.0000
4. Normal-Control	0.3304	0.0000	0.0000	1.0000

Table 21 (continued)

ANOVA and Scheffé Test for Three CRS Groups and Control Group on CNS Variables

Irritability

ANOVA

Source	SS	MS	DF	F	P
Groups	116.6286	38.88	3	60.58	0.000001
Error	42.3571	0.64	66		

Probability matrix for Scheffé multiple comparison of means

	1	2	3	4
1. Normokinetic	1.0000	0.0000	0.0000	0.5084
2. Hyperkinetic	0.0000	1.0000	0.0000	0.0000
3. Hypokinetic	0.0000	0.0000	1.0000	0.0000
4. Normal-Control	0.5084	0.0000	0.0000	1.0000

Explosiveness

ANOVA

Source	SS	MS	DF	F	P
Groups	116.7172	38.91	3	42.69	0.000001
Error	60.1542	0.91	66		

Probability matrix for Scheffé multiple comparison of means

	1	2	3	4
1. Normokinetic	1.0000	0.0000	0.0000	0.3985
2. Hyperkinetic	0.0000	1.0000	0.0000	0.0000
3. Hypokinetic	0.0000	0.0000	1.0000	0.0045
4. Normal-Control	0.3985	0.0000	0.0045	1.0000

Table 22

ANOVA and Scheffé Test for Three CRS Groups
and Normal Group on Three Cognitive Variables

Figure Copying Test

ANOVA

Source	SS	MS	DF	F	P
Groups	69.4570	23.15	3	3.52	0.010
Error	433.7460	6.57	66		

Probability matrix for Scheffé
multiple comparison of means

	1	2	3	4
1. Normokinetic	1.0000	0.9994	0.8701	0.0493
2. Hyperkinetic	0.9994	1.0000	0.9194	0.0732
3. Hypokinetic	0.8701	0.9194	1.0000	0.3006
4. Normal	0.0493	0.0732	0.3006	1.0000

Free recall

ANOVA

Source	SS	MS	DF	F	P
Groups	937.6875	312.56	3	4.14	0.009
Error	4986.1875	75.55	66		

Probability matrix for Scheffé
multiple comparison of means

	1	2	3	4
1. Normokinetic	1.0000	0.9999	0.7831	0.0355
2. Hyperkinetic	0.9999	1.0000	0.7535	0.0329
3. Hypokinetic	0.7831	0.7535	1.0000	0.3288
4. Normal	0.0355	0.0329	0.3288	1.0000

Table 22 (continued)

ANOVA and Scheffé Test for Three CRS Groups and Normal Group on Three Cognitive Variables

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Serial recall

ANOVA

Source	SS	MS	DF	F	P
Groups	3895.0000	1298.33	3	4.70	0.004
Error	18238.1880	276.34	66		

Probability matrix for Scheffé multiple comparison of means

	1	2	3	4
1. Normokinetic	1.0000	0.9478	0.6392	0.0507
2. Hyperkinetic	0.9478	1.0000	0.3299	0.0123
3. Hypokinetic	0.6392	0.3299	1.0000	0.5517
4. Normal	0.0507	0.0123	0.5517	1.0000

on Figure Copying between the normokinetic and control groups ($p < 0.04$), on free recall between the normokinetic and control groups ($p < 0.03$) and between the hyperkinetic and control groups ($p < 0.03$), and on serial recall between the hyperkinetic and control groups ($p < 0.01$). It may be noted that the above differences were obtained between the control group and the learning disabled groups and not between the learning disabled groups themselves.

Relationship Between Physiological and Behavioral Arousal

One of the main objectives of the study was to investigate the relationship between behavioral and physiological arousal. To accomplish this, a Pearson's r was computed between the transformed factor scores of the GSR and CRS; the r was -0.378, $p < 0.01$. This negative correlation suggests that a child that is behaviorally overaroused (the hyperactive child) is in fact physiologically underaroused. To investigate this inverse relationship further, the following steps were taken:

1. A scatter diagram between the three learning disabled groups on the CRS and GSR factor scores was drawn, which is represented in Figure 18, showing that the inverse relationship is quite evident. Of the group of 17 hyperkinetic children, only one was found to be POA. Eight were found to be PNA, while the other eight were found to be PUA. This finding essentially replicates that of Satterfield and Dawson (1971) who found 50 per cent of their 24 hyperkinetic children to be PUA.
2. A two-group one-way fixed-effects MANOVA was conducted between the POA group and the hyperkinetic group on the seven GSR variables and

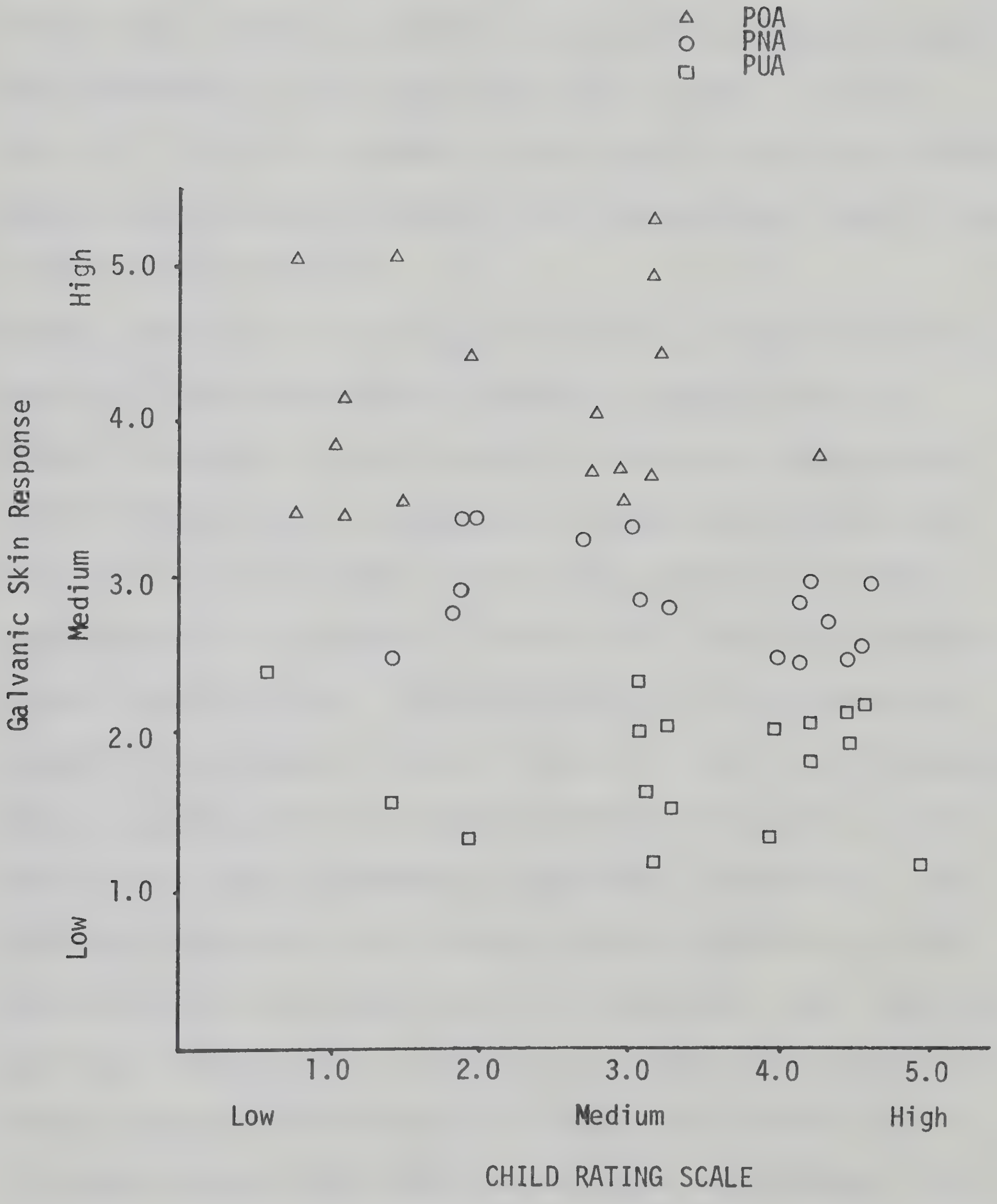

Fig. 18. A scatter diagram of GSR and CRS factor scores of learning disabled children as defined by scores on GSR

then on the six CRS variables. On the GSR variables, a significant difference was found between the groups with a Wilk's Lambda = 0.30 and $\underline{F}(7, 26) = 8.58$ ($p < 0.00001$). On the CRS variables, a significant difference was also found with a Wilk's Lambda = 0.29 and $\underline{F}(6, 27) = 10.96$ ($p < 0.000003$). These results confirm that the POA group is significantly different from the hyperkinetic group on both the GSR and CRS variables.

3. Finally, the scaled scores of the CRS and GSR variables for both the hyperkinetic and POA groups are plotted in Figures 19 and 20. Figure 19 represents a profile analysis between the two groups on the six CRS variables. As expected, the hyperkinetic group have high scores on all variables, but the POA group is consistently opposite on all six variables, with the least difference occurring on short attention span. A profile analysis of the GSR variables between the two groups is given in Figure 20. On all seven components they are opposite with the greatest difference occurring on basal level and the least difference on spontaneous fluctuations. The hyperkinetic group has a GSR response pattern resembling the PUA characterized by a low basal level, long latencies, small magnitude and a quick recovery limb. Figure 21 illustrates the similarity of the GSR response pattern between the hyperkinetic and PUA groups.

The above results have clearly demonstrated the existence of an inverse relationship between physiological and behavioral arousal. This relationship has several important implications regarding etiology, and management of the hyperkinetic child. These implications will be discussed in the next chapter.

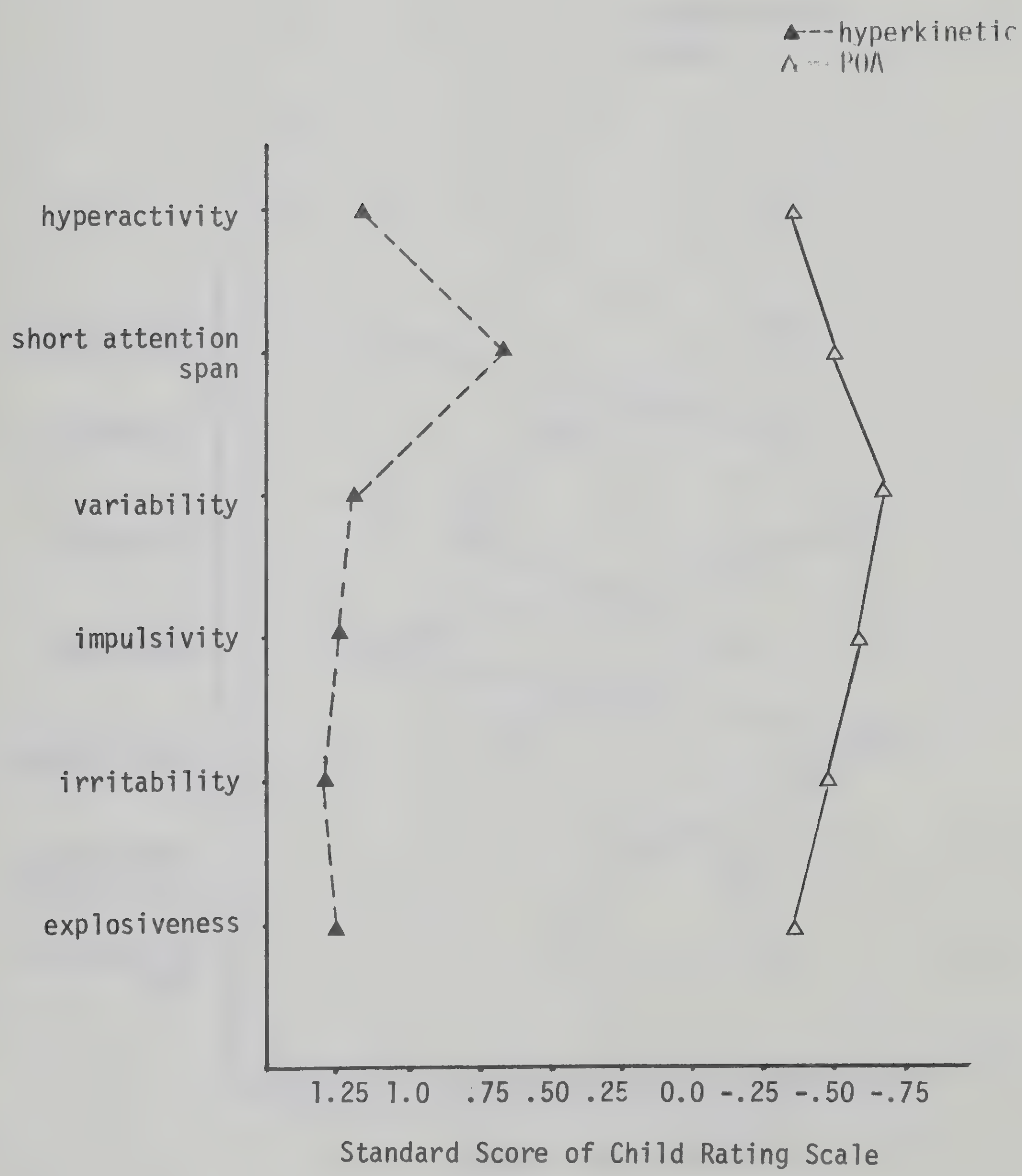

Fig. 19. Profile analysis of Child Rating Scale variables in hyperkinetic and physiologically overaroused children

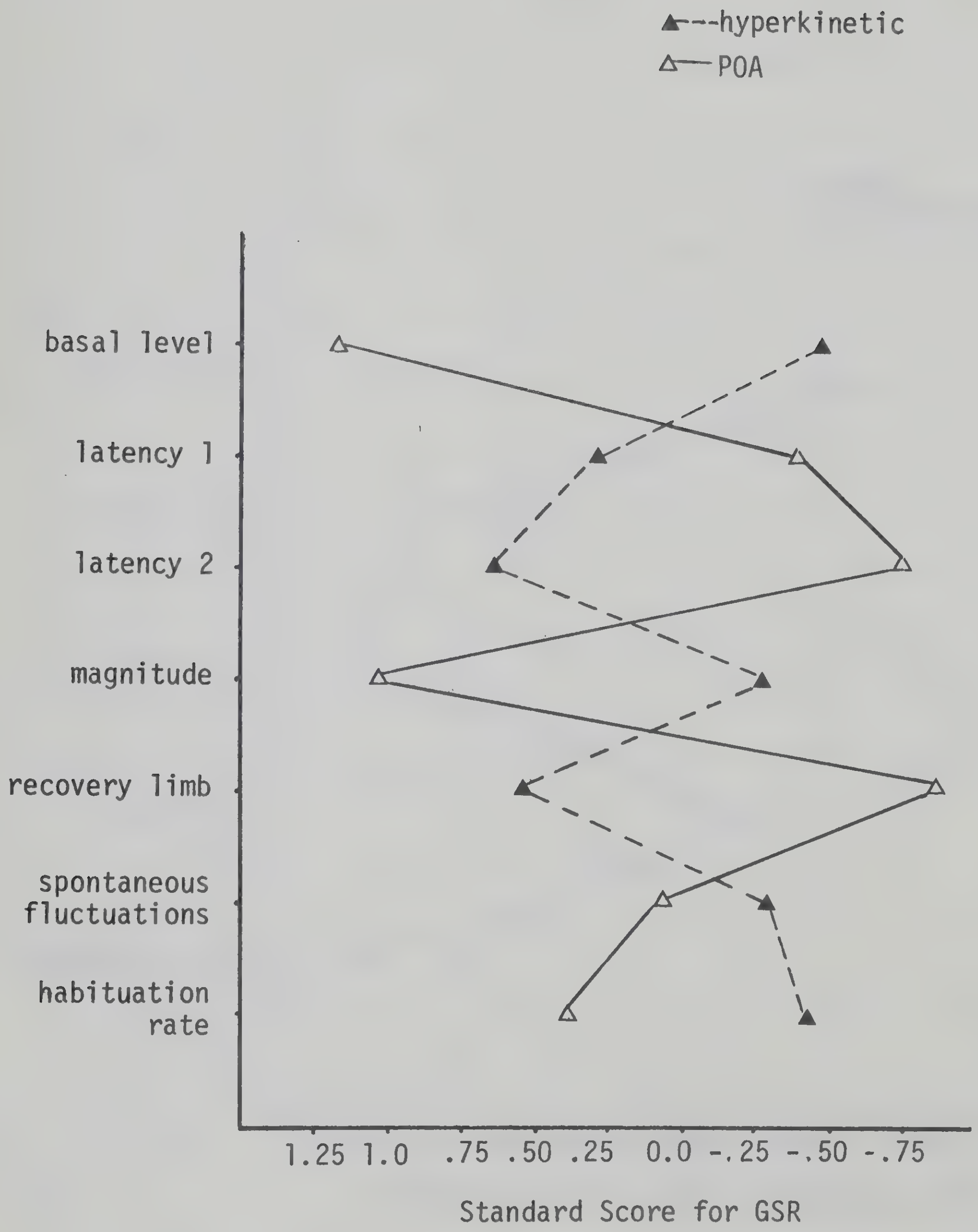

Fig. 20. Profile analysis of GSR components in physiologically overaroused and hyperkinetic children

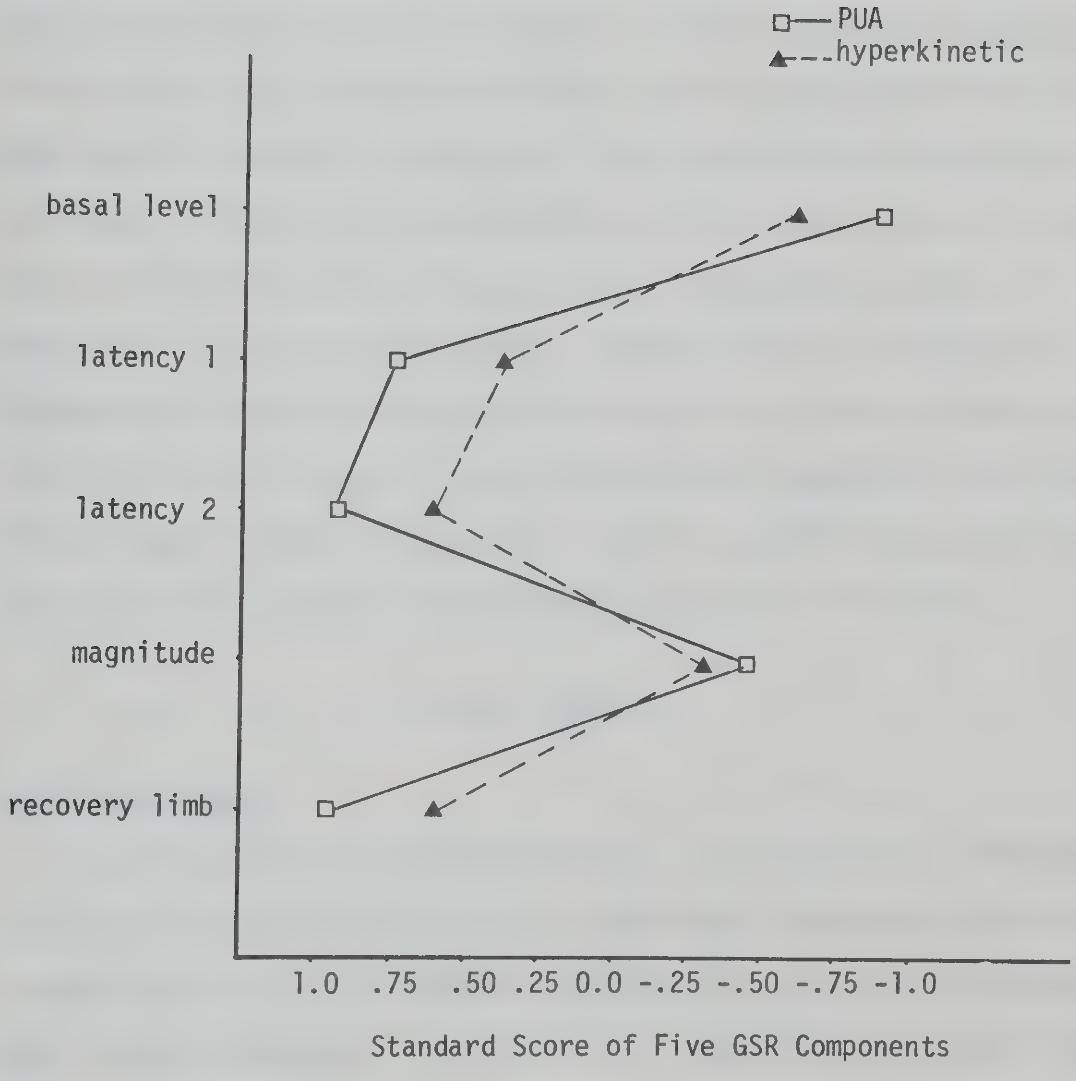

Fig. 21. Profile analysis of GSR components in physiologically underaroused and hyperkinetic children

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CHAPTER VI

DISCUSSION

The results of this study are discussed in four sections. In the first section, the two arousal measures are discussed in terms of the factor analysis and univariate analysis of their respective components. Following this, the inverse relationship found between behavioral and physiological arousal is considered. The third section discusses the performance of learning disabled children on the cognitive tasks, in the light of which the poor performance of the hyperkinetic children is attributed to an attentional deficit. Other aspects of information integration in learning disabled children were considered by comparing the results of the present study with two others conducted at the Centre for the Study of Mental Retardation. The last section discusses certain theoretical and practical implications arising from the results.

Arousal Measures

Child Rating Scale

It will be recalled (see Chapter II, p. 19) that Werry (1968) had recommended the use of empirical and statistical techniques to help to delineate and clarify the behaviors symptomatic of children with severe motor activity problems. In line with his suggestion, the present study: (1) used a child rating scale consisting of the six most common behaviors associated with hyperkinetic children, and (2) factor analyzed the rating scale. The result, as mentioned before, was that the six behaviors in the scale loaded on one factor. However, without the benefit of factor

analysis, for many years, research workers have suggested that these behaviors are generally found together (O'Malley & Eisenberg, 1973; Stewart, Pitts, Craig & Dieruf, 1966). The study by Schrager, Harrison, McDermott and Killins (1966), who were able to validate the behavioral correlates of hyperkinesis, is typical of this kind of research. In a survey involving 500 children, 79 professionals, including teachers, psychologists, psychiatrists, pediatricians and social workers, were asked to complete a behavioral checklist containing 55 items, choosing from the list characteristics which they thought were relevant to the term 'hyperkinesis'. They were also asked to list the six most common. Despite the ambiguity that surrounds hyperkinesis, a good interdisciplinary consensus of opinion was found: 75 per cent or more of the professional groups concerned listed the same six behaviors as primary to hyperkinesis. These behavioral signs were: fidgets and restless, inattentive, hard to manage, can't sit still, easily distracted,and low frustration. These six items are quite similar to the items in the child rating scale used in the present study which were: hyperactivity, short attention span and poor powers of concentration, variability, impulsiveness and inability to delay gratification, irritability, and explosiveness (see Appendix A).

Since the six behaviors form a unitary syndrome, any diagnosis of hyperkinesis should consider the extent to which these are observed upon clinical examination.

The WHO Seminars on Classification in Child Psychiatry recommend the use of a triple-axial classification sceme (Rutter, Lebovici, Eisenberg, Sneznevsky, Sadoun, Brooke & Lin, 1969; Tarjan & Eisenberg, 1972); the first axis of this is similar to the syndrome described by

our factor analysis. Axis I specifies the clinical psychiatric syndrome; Axis II describes the level of intellectual functioning of the child; and Axis III notes any associated or etiological factors. It was suggested by WHO that there was a need for the category 'hyperkinetic syndrome', the primary characteristics being: extreme overactivity, distractibility, short attention span, impulsiveness, marked mood fluctuations, and aggression. It was also emphasized that the term be used as a descriptive category, as there was uncertainty as to its nature, and it was therefore placed in Axis I of the classification scheme.

GSR

It may be recalled that in Chapter III two hypotheses in relation to GSR were proposed. The first one predicted that the three physiologically aroused groups would differ significantly on all GSR components, while the second predicted that the control group would not differ from the physiologically normally aroused group on any of the components. This latter hypothesis was found to be true in all cases, while the former hypothesis was not supported in regard to each and every component of GSR. The hypothesis was supported by differences in basal level and latency 2 (which is the duration of GSR from evocation to peak). Partial support was found on latency 1 (evocation time), where significant differences were seen between: (1) physiologically overaroused and physiologically underaroused groups, and (2) between physiologically underaroused and physiologically normally aroused groups. On magnitude significant differences were found between physiologically overaroused

and physiologically underaroused groups; the two groups differed also on habituation rate. While significant differences were found between the three physiologically aroused groups on recovery limb, it was in the reverse direction to what was hypothesized, i.e., the physiologically overaroused group had a quicker recovery limb than the other groups. No support for the hypothesis was obtained on spontaneous fluctuations.

The findings concerning basal level and recovery limb might be understood in terms of the recent work of Fowles (1974) and Edelberg (1966, 1970) on electrodermal activity. Fowles (1974) maintains that there are two effector mechanisms for the production of a GSR. One is an increase in the filling of the sweat gland ducts, which occurs usually in states of low arousal when the sweat glands are relatively empty. Secondly, there is a change in membrane potential occurring in the epidermal layer of the skin. This change is said to be a major contributor to phasic GSRs, when the sweat glands are relatively full under states of high arousal. The sweat glands and ducts of a child that is in a state of high physiological arousal are fairly constantly full, thus allowing for a constant high conductance of electricity.

The result is an elevated basal level, which was found to be the strongest discriminatory measure between the three different physiologically aroused groups. In the light of Fowles' (1974) interpretation of electrodermal activity, then, this finding is not at all surprising. In regard to recovery limb of a GSR, Edelberg has found that a quicker recovery limb is a function of cognitive and goal-directed behavior. The converse of the hypothesis concerning the recovery limb, then, suggests that in a low state of physiological arousal, a person is not

as attentive and goal-directed as individuals with high levels of arousal. Our findings are in agreement with this.

During the experimental situation, the three physiologically aroused groups and control group did not differ in spontaneous fluctuations. Originally it was hypothesized that arousal level will be reflected in the number of expected differences in fluctuations (see Surwillo & Quilter, 1965; Brivllova, 1965). However, the fact that no significant differences were found in the present investigation might well be a function of the experimental situation, where the subject is not required to physically respond to stimuli or become involved cognitively, but simply rests. In fact, Cohen and Douglas (1972) report a similar finding. During periods of rest and simple auditory stimulus presentations, hyperkinetic and control subjects did not differ on OR components, including frequency counts. Differences were found, however, when subjects were involved in a delayed reaction time task. Parsons and Chandler (1969) investigated the GSR during rest periods and reaction time tasks in brain-damaged and non-brain-damaged patients. They found that brain-damaged patients had significantly higher skin conductance level at rest, as well as a higher incidence of nonspecific GSRs.

Behavioral and Physiological Arousal: An Inverse Relationship

The inverse relationship found in the present investigation concurs with the recent studies of Satterfield and colleagues (Satterfield & Dawson, 1971; Satterfield, Cantwell, Saul & Lesser, 1972; Satterfield, Atoian, Brashears, Burleigh & Dawson, 1974). Satterfield's studies are

of direct importance to the present study,[1] since he used both the GSR and a child rating scale as measures of arousal. As previously discussed in Chapter II, the Satterfield and Dawson (1971) study found hyperkinetic children to have lower basal skin conductance, fewer and smaller nonspecific GSRs and smaller specific GSRs than those of controls. Satterfield _et al_. (1974) investigated skin conductance levels and certain maladaptive classroom behaviors, as indicated on a child rating scale by teachers of 18 hyperkinetic children. The teachers rated the children on 30 items of classroom behavior, and it was found that the hyperkinetic children with the lowest skin conductance level exhibited more maladaptive behavior.

As stated earlier, the results of the present study agree with Satterfield's work, but the present investigation could be considered more informative for the following reasons:

1. In Satterfield's studies, the GSR measure was skin conductance and level, frequency of specific and nonspecific GSR. In the present experiment, we have used a composite score, derived from five indices of GSR.
2. The rating scale for teachers, used by Satterfield, consisted of 36 items of classroom behavior arranged in checklist form, which allowed the teacher to check off whether the child exhibited each individual item of behavior: (1) not at all, (2) just a little, (3) moderately, or (4) very much. These items were given scores of 0, 1, 2 and 3 respectively, and were then summed up to give a total rating across

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[1] It should be pointed out that the present investigation was designed prior to the publication of Satterfield's recent findings.

all items of behavior. Thus, the diagnosis of a hyperkinetic child was indicated by a high score on the scale. The hyperkinetic children for the present study were identified by factor scores based on the child rating scale (see Chapter IV for details), a more reliable method of identifying the hyperkinetic child.

3. Satterfield _et al_. (1974) correlated the skin conductance level of 18 hyperkinetic children with individual items of maladaptive classroom behavior, which were: 'restlessness', 'easily distracted', 'does not follow directions', 'talks a lot', and 'irritable'. In each case, a significant negative correlation was obtained with $p < 0.01$ for 'does not follow directions' and 'talks a lot', and $p < 0.05$ for the three remaining behaviors. The negative correlation obtained in the present study was -0.378, significant at the .01 level, but the main feature here is that the correlation was made between factor scores, where the GSR factor score represented the five GSR components, and the child rating factor score represented six behaviors.

Other physiological measures have demonstrated low physiological arousal in hyperkinetic children. EEG studies, for example, with slow waves in the EEG being associated with underarousal, have been conducted with hyperkinetic children. Satterfield, Cantwell, Saul, Lesser and Podosin (1973) studied neurological examinations, EEG findings and behavioral responses to methylphenidate treatment in 57 hyperkinetic children. On the basis of the EEG results, the children were divided into three groups: normal, borderline and abnormal. The abnormal EEG was defined by excessive slow wave activity. It was found that hyperkinetic children with abnormal EEGs responded better to methylphenidate than those with normal EEGs.

Stevens, Sachdev and Milstein (1968) studied the EEGs of children with behavior disorders and found a positive correlation between hyperkinesis, poor attention and slow occipital waves. Wickler, Dixon and Parker (1970) also found excessive slow wave activity in hyperkinetic children. More recently, Grunewald-Zuberbier, Grunewald and Rasche (1975) investigated the relationship between behavioral arousal of hyperkinetic children and EEG arousal. They found that hyperkinetic children showed a lower degree of EEG activation in stimulus-free periods,as evidenced by a smaller number and lower mean frequency of beta waves, larger alpha and beta amplitudes, and a larger number of alpha waves.

Amphetamine studies have further supported the idea of a state of underarousal in hyperkinetic children. The reader is referred to Werry, Sprague, Weiss and Minde (1970), who provide an excellent review of 16 clinical and laboratory studies of psychotropic drugs with children, many of which suggest that hyperkinetic children are physiologically underaroused, based on the positive behavioral effects of stimulating drugs on the children. Wender (1971) also concurs with this view.

Satterfield and Dawson (1971) researched the effect of methylphenidate on skin conductance level and found that hyperkinetic children with slow skin conductance level responded better to medication, as evidenced by increased skin conductance level. A further study by Satterfield, Lesser and Podosin (1972) investigated the effect of methylphenidate on skin conductance level and two other indices of CNS arousal: (a) the resting EEG, and (b) the sensory evoked cortical response. It was found that hyperkinetic children with a low skin conductance level and slow EEG waves responded better to methylphenidate, with increases in the electro-

physiological measures indicated above. Furthermore, methylphenidate was found to produce a greater behavioral improvement in physiologically underaroused hyperkinetic children, as witnessed by the teachers' rating scales.

Information Processing

When the learning disabled children are compared among themselves on cognitive tasks, whether they are grouped physiologically or behaviorally, they do not differ in successive or simultaneous modes, or speed of information integration. It is only when they are compared with the normal control group that significant differences are found. Several trends concerning information integration appear. The hypokinetic children do not differ on any of the cognitive tasks when compared to the control group, while both the normokinetic and hyperkinetic perform poorly on both serial and free recall. Since the hyperkinetic child will always be separated from the others in the class by the teacher, it is important to know the significance of their performance on cognitive tasks. It is upon this group of children that the discussion will now concentrate.

It appears that the hyperkinetic children experience difficulty in successive information integration, as indicated by their performance on serial recall and free recall. However, they did not differ from the control group on another test of successive processing, the digit span. A reason for this might be that the children constantly use numbers, and that the numbers on the task were more familiar than the words on the recall task.

When the learning disabled children were grouped on physiological arousal, the only significant difference was between the control group and the physiologically underaroused, on both free recall and serial recall. Therefore, in the light of the inverse relationship, it might be said that hyperkinetic children, who are usually physiologically underaroused, have difficulty on successive tasks.

Several investigators have indicated that hyperkinetic children do poorly in school because of an attentional deficit (Dykman et al., 1971; Cohen & Douglas, 1972; Tarver & Hallahan, 1974), and it might be that the poor performance on successive tasks by the hyperkinetic children is in fact an indication of poor attention. The nature of successive tasks certainly requires the child to concentrate for a period of time, during which the child holds information presented serially, which he later recalls. Thus, if it is an attentional deficit, evidence should be forthcoming by studying the OR, since the OR is considered a good measure of attention (Luria, 1963; Sokolov, 1960; Lynn, 1966).

In light of the inverse relationship, the results of the study do support an attentional deficit in the hyperkinetic child. The OR measure that was used in the present investigation was the components of GSR to the stimulus word BOY. Generally speaking, a weak OR is anticipated. When grouped on physiological arousal, the only group to significantly differ from the control group is the physiologically underaroused, exhibiting a slower habituation rate, a quicker recovery limb, a faster latency 2 and a lower basal level. Habituation rate and recovery limb of the OR have been traditionally related to attentional deficits;

therefore, these components will now be discussed.

Habituation rate

Habituation of the OR has been investigated to explain attentional deficits (Luria, 1963; Lynn, 1966).

Once again, bearing in mind the inverse relationship, both the physiologically underaroused and hyperkinetic groups habituate faster than the other groups. While a significant difference is found only when the learning disabled children are grouped on physiological arousal, and then only between the control and physiologically underaroused ($p < 0.04$), the trend in the rate of habituation is the same when the children are grouped behaviorally (see Figure 21a and 21b).

The hyperkinetic child has been seen to have a rapid rate of habituation, the possible cause of which might be poor inhibitory control from the cortex. In terms of Sokolov's model, then, there is insufficient inhibition control in the cortex; the information entering the reticular formation is blocked very quickly, resulting in rapid habituation of the OR. This explanation ties in with the earlier explanation of inhibition-excitation imbalance found in the hyperkinetic child. The hyperkinetic child habituates quickly and does not, therefore, attend to the stimulus for a long enough period of time for the development of strong connections between all aspects of the stimulus. Likewise, he does not attend sufficiently to the task at hand, resulting in poor performance.

Recovery limb

Poor attention has also been associated with the recovery limb of the OR (Edelberg, 1966, 1970). Of the three physiologically aroused groups,

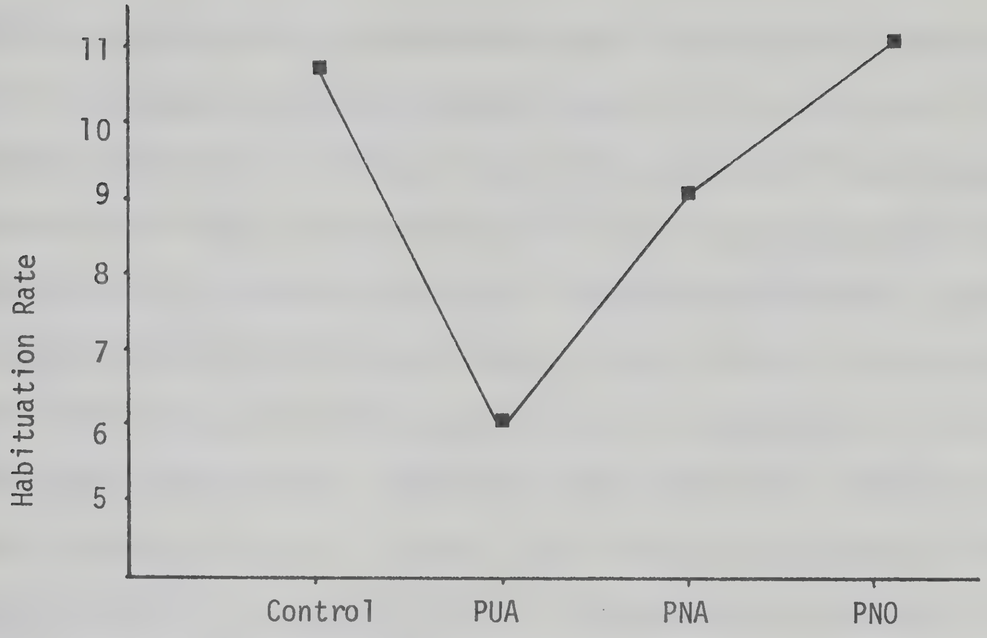

Fig. 21a. Mean habituation rate of three PA and control groups

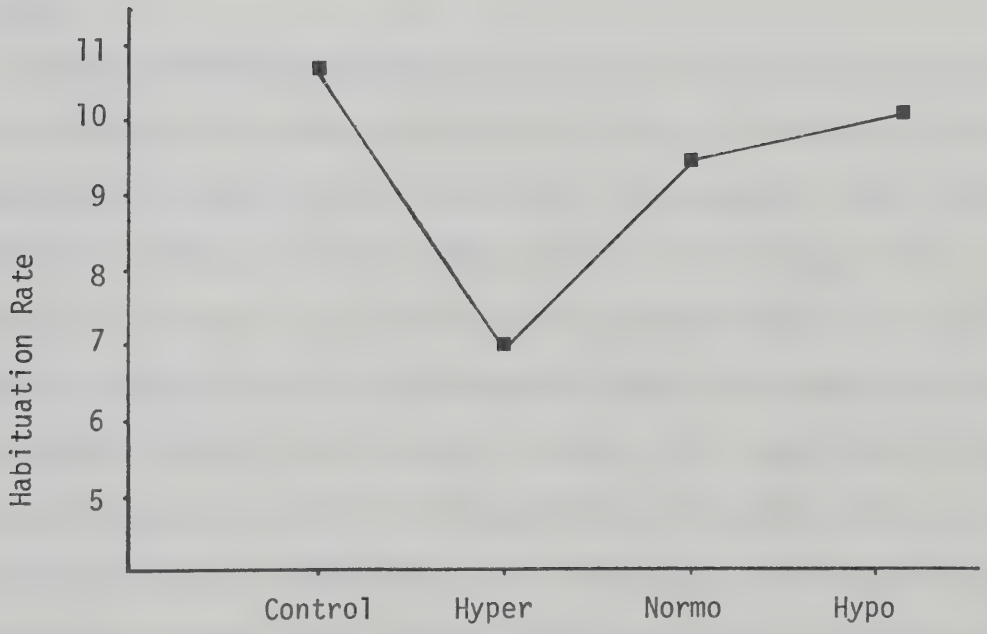

Fig. 21b. Mean habituation rate of three CRS and control groups

only the physiologically underaroused group significantly differs from the control group ($p < 0.001$), having means of 11.6 seconds and 5.8 seconds respectively. No significant differences were found between the control or the learning disabled children when grouped behaviorally. Nevertheless, the trend is the same: both the physiologically underaroused and hyperkinetic groups have a slower recovery limb than the three other groups, the importance of which is seen when one considers the inverse relationship. Edelberg (1970) showed that individuals with faster recovery rates also showed slower habituation of electrodermal responses, which is certainly true of the hyperkinetic children in this study. These children tend to have both a faster rate of habituation and a slower recovery limb of the GSR, two indicants of poor attention.

Latency

Latency differences between experimental groups have not usually been associated with attentional deficits, but in the light of Edelberg's hypothesis, it might not be unreasonable to assume so. Thus, during cognitive activity, when the sweat glands and ducts become full, a faster latency of response, as well as a faster recovery limb, will occur. In fact, the correlations obtained between latency 1 and recovery limb was .47, and between latency 2 and recovery limb was .68. Significant differences occurred between the control and physiologically underaroused ($p < 0.001$), the control having a mean latency of 1.9 seconds, and the physiologically underaroused a mean of 3.2 seconds. When the learning disabled children were grouped behaviorally, an overall significance was found ($p < 0.05$), but the Scheffé test revealed no significant difference between the hyperkinetic and control groups; the trend was in the right direction.

A longer latency between evocation and peak for the hypoaroused children implies a weak orienting response.

The normokinetic group was also found to be significantly poorer in their performance on successive tasks than the control group. However, the same explanation, i.e., an attention deficit in terms of OR on physiological explanations, cannot be given in terms of physiological arousal, since no difference could be found, A possible reason may be that these children have problems in academic work that are situational in origin.

Comparison with previous studies

Several comparisons were made with existing data based on 60 children of normal intelligence with no learning problems (Jarman, 1975), and a group of 58 children with a severe reading deficit. These comparisons were made in order that: (1) a broader perspective be obtained on the nature of information processing in learning disabled children, and (2) that the Jarman (1975) and Leong (1975) studies be expanded on sample characteristics. The three groups were comparable in IQ.

Table 26 shows the mean comparisons on cognitive tasks between the normal group and the hyperkinetic group. The latter group was significantly inferior on Figure Copying, free and serial recall, but not on Raven's Progressive Matrices. The results of comparison with the normal children in Jarman's (1975) study are obviously reliable, considering the larger number of children who were studied; our own control children were only 19. It appears, then, that hyperkinetic children have difficulty in both modes of information integration, not just in successive synthesis, as the results using only the data of the present investigation would

Table 23

Mean Comparisons on Cognitive Tasks Between Hyperkinetic and Normal Groups

	Hyperkinetic[1] (N = 17)		Normals[2] (N = 60)		
Task	Mean	SD	Mean	SD	t
Raven's Progressive Matrices	26.58	3.89	26.08	5.04	0.375
Figure Copying	12.05	2.70	14.55	2.46	3.62***
Free recall	82.05	11.11	88.60	6.58	3.04**
Serial recall	67.17	22.82	78.30	17.16	2.18*

[1] Hyperkinetic: Age = 130 months; IQ = 97.7; SD = 10.1

[2] Normals: Age = 112 months; IQ = 101.3; SD = 3.7

***$p < .001$
**$p < .01$
*$p < .05$

suggest.

Comparisons on cognitive tasks between the learning disabled group and the normal group in Jarman's (1975) study are found in Table 27. The former group did significantly poorer in Figure Copying and in free recall, tasks which represent modes of simultaneous and successive synthesis. Table 28 contains the mean comparisons on cognitive tasks between the learning disabled group and the group with a severe reading deficit (Leong, 1974). The latter group was significantly inferior on Raven's Progressive Matrices and serial recall. Thus, it appears that the normals, learning disabled and the reading deficient can be arranged in a hierarchy in terms of their performance on some of the cognitive tasks.

Table 24

Mean Comparisons on Cognitive Tasks Between Learning Disabled and Normal Groups

Task	Learning Disabled[1] (N = 51)		Normals[2] (N = 60)		t
	Mean	SD	Mean	SD	
Raven's Progressive Matrices	27.0	4.14	26.08	5.04	1.05
Figure Copyng	12.2	2.60	14.55	2.46	4.93**
Free recall	83.17	9.87	88.60	6.58	2.98*
Serial recall	71.76	18.92	78.30	17.16	1.94

[1] Learning disabled: Age = 128 months; IQ = 98.8; SD = 7.6

[2] Normals: Age = 112 months; IQ = 101.3; SD = 3.7

**$p < 0.01$
*$p < 0.05$

Table 25

Mean Comparisons on Cognitive Tasks Between Learning Disabled and Reading Deficit Groups

Task	Learning Disabled[1] (N = 51)		Severe Reading Deficit[2] (N = 58)		t
	Mean	SD	Mean	SD	
Raven's Progressive Matrices	27.0	4.14	22.60	5.04	4.99**
Figure Copying	12.22	2.60	12.20	2.50	0.04
Serial recall	71.76	18.92	57.12	12.22	4.91**

[1] Learning disabled: Age = 128 months; IQ = 98.8; SD = 7.6

[2] Severe reading deficit: Age = 111 months; IQ = 102.4; SD = 11.5

**$p < 0.01$

The original hypothesis concerning information processing deficits in learning disabled children was only tentative, based on the work of Strauss. It was expected that the hyperkinetic children would experience difficulty on simultaneous tasks. Using the data from this study, the hypothesis could not be supported. Rather, in addition to simultaneous tasks, the hyperkinetic group were inferior to the normals on successive tasks. Furthermore, the learning disabled group was superior to the group with reading deficits in both simultaneous and successive tasks. It can be said that cognitive deficits should better be explored between a group of normal and a group with specific reading problems, rather than considering a heterogeneous group of learning disabled children. The cognitive problems of an amorphous group of children labelled as 'learning disabled' are less characteristic than their arousal characteristics.

Theoretical and Practical Implications

Theoretical implications

The theoretical interpretations of hyperkinetic behavior are diverse, but most of these posit organic dysfunctions. O'Malley and Eisenberg (1973), in reviewing the literature on hyperkinetic behavior, conclude that the term hyperkinesis describes a heterogeneous group of children with different etiologies, since hyperkinetic behavior represents "a final common pathway for the expression of diverse pathologies". The pathology is certainly organic for Werry (1972), who advocates that hyperkinesis is due to structural abnormalities of the brain. Elaborating on structural defects, one may consider Cantwell's (1973) suggestion that

it is genetically based and the suggestion of Wender (1971) that it is a biochemical disorder. The results of the present investigation are not inconsistent with an organic explanation. The hyperkinetic child is found to be physiologically underaroused. What has to be worked out further is the relation between a theory of low physiological arousal and the hyperkinetic behaviors of the child.

A major explanation for the relationship might be provided in terms of Luria's theory of an imbalance between excitation-inhibition (see Chapter II). Low CNS arousal results from an imbalanced state in which inhibition predominates. When the level of CNS inhibition is high, behavioral arousal is predicted to be high. In other words, low CNS excitation implies poorer control over behavior. A paradoxical relation thus exists between cortical arousal and behavioral arousal. Satterfield's (Satterfield *et al.*, 1974) research involving EEG and GSR changes certainly is in agreement with this; poor inhibitory control over motor activity results in the excessive behaviors commonly found in the hyperkinetic child: hyperactivity, restlessness and excitability.

As poor inhibitory control over motor functions may manifest itself in hyperactivity, poor control over sensory functions may result in poor concentration, short attention span, distractibility, and impulsiveness. Again, the research reported by Satterfield *et al.* (1974) would concur with this, since they found that children with low skin conductance level were more impulsive, more distractible, and had the poorest attention span, in addition to more than normal motor activity.

Another line of work, the effect of stimulant drugs, offers support to the inverse relation between cortical inhibition and behavioral arousal.

The positive behavioral responses to stimulant medication can be explained in terms of poor CNS inhibition. Methylphenidate has been found to increase CNS arousal and in doing so also raises CNS inhibitory controls of the child. Therefore, a decrease in motor activity is observed along with more goal directed behavior (Millichap & Boldrey, 1967; Millichap, 1973). The child's sensory activity is also improved, as witnessed by increased attention and response to relevant stimuli (Connors, 1971; Connors, 1972). Of course, one has to recognize the vast individual differences which exist among the behaviorally hyperactive children in regard to their response to stimulant drugs.

Support for the explanation that hyperkinetic children have poor CNS inhibitory control has been obtained from studies using animals. Morruzzi and Magoun (1949) and Hernandez-Peon (1961) have demonstrated that the reticular formation acts both as an arousal centre and an inhibitory centre. This was accomplished by stimulating the reticular formation, the effects of which were found to increase cortical arousal and also increase the inhibition of sensory signals at synapses in the sensory pathways. Furthermore, stimulation by drugs (Killan, 1962) produced the same kinds of results. Walley and Weiden (1973) have developed a neuropsychological theory of attention, aspects of which have relevance to this discussion. On the basis of animal and human research, they have suggested that CNS arousal and cortical inhibition vary together. Thus, an increase in arousal enhances one's ability to focus attention by a "facilitation of cortical recurrent inhibition (Walley & Weiden, 1973)".

The inverse relationship between physiological arousal and hyperkinesis

has been attributed to one of low CNS arousal and poor CNS inhibitory control. How is this inverse physiological relationship experienced in the psychological plane? Teachers often suggest that the hyperkinetic child lacks the inner control over motor and sensory activity; he responds to stimuli from within and does not consider the restrictions put upon his behavior by the environment.

Management Implications

Since the early studies of Bradley (1937) and Bradley and Bowen (1941), the use of drugs has been the primary tool in the management of hyperkinetic behavior. While a critical survey of drug treatment is not tendered here, the reader is referred to several excellent reviews (Fish, 1968; Freeman, 1966; Conners et al., 1972; Werry & Sprague, 1972; Strouffe, 1975). Of the drugs most commonly used, the stimulants methylphenidate and dextroamphetamine have been shown to be the most successful, having the effect of decreasing activity level and increasing attention span (Conners et al., 1967). However, stimulant medication does not work in all cases (Fish, 1975), and it is to this factor that the present study has relevance. Satterfield (Satterfield & Dawson, 1971; Satterfield et al., 1973) has suggested that stimulants work best in hyperkinetic children that are physiologically underaroused. Das (1973) has suggested the theoretical possibility that hyperkinetic children may indeed be cortically inhibited. If this is the case, then knowledge of the state of physiological arousal should be known before medication is recommended. The stimulant has the effect of raising the physiological arousal level. Thus, if a child is underaroused, then the level of arousal

will be raised towards a 'normal' level, resulting in a decrease in activity and impulsiveness, and increasing attention and concentration. However, the stimulant medication has also been demonstrated to increase the hyperkinetic behavior in children (Simmons, 1975). A reason for this might be that the arousal level in these children was normal or higher before medication, and the behavior was merely a reaction to the situation. Therefore, the stimulant simply increased the arousal level, resulting in the heightening of hyperkinetic behavior. This study has shown that physiological arousal can be measured and that different levels do exist, but the use of the GSR is still a research tool, and more work is needed in developing it as a standard diagnostic tool.

Drug treatment, however, should not be considered as the only method. One should look beyond medication because of:

1. The significant number of children that do not respond to medication (Simmons, 1975).
2. The lack of knowledge concerning long-term effects and, more importantly, the side effects of medication on individuals (Strouffe, 1975).
3. The contributing influence of the environment on hyperkinetic behavior.

It is not surprising, therefore, that behavior modification techniques have been used with hyperkinetic children. Several studies have reported success (Patterson, 1965; Hall, Lund & Jackson, 1968; O'Leary & Drabman, 1971), in particular the studies using token economy in the classroom. Thus, a structured environment, along with systematic reinforcement, appears helpful in managing disruptive behavior.

Werry (1968) has pointed out that one treatment may not be sufficient

for managing hyperkinetic behavior, due to the fact that hyperkinetic children are often multiply handicapped. Sprague and Werry (1971) suggest that a combination of drug treatment and behavior modification might be necessary for some children. Indeed, Christensen and Sprague (1973) did investigate the combination of these two treatments with hyperkinetic children. They compared six children receiving behavior modification and placebo, and six children receiving behavior modification and methylphenidate with seat activity and daily quizzes as outcome measures. Results showed that seat activity was reduced in both groups by the application of contingent reinforcement, but the subjects who received methylphenidate displayed consistently lower rates of movement than the placebo group. The study by Christensen and Sprague (1973) has provided some evidence that both treatments can be used jointly with some children, and has provided a basis for further investigations in this approach.

The initial concern of people involved with hyperkinetic children, such as teachers, parents and pediatricians, is the control of the hyperkinetic behavior. Two approaches most commonly used have been discussed, emphasizing the need for a thorough understanding of the cause of the hyperkinesis before a management technique is undertaken. For example, if the hyperkinetic child is physiologically underaroused, then medication might be the only technique that will obtain success. On the other hand, where hyperkinesis is situational in origin, then environmental change via behavior modification might be the answer. In some children, a combined approach of medication and behavior modification will be required.

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APPENDIX A

Appendix A

Child Rating Scale for Hyperkinesis (Davids, 1971)

Child's Name______________________________ Birth Date____________

Rater's Name______________________________ Date of Rating___________

Please rate the child on each of the characteristics listed on the following scales. Place a check mark at the point on the scale indicative of your estimate of the degree to which the child possesses the particular characteristic.

As you make each rating, judge the child in comparison with other children of the same sex and age. That is, the ratings should indicate your estimate of the child's behavior in comparison with the behavior displayed by other "normal children".

For each of the characteristics, which are defined below, place a check mark at one of the six points on the scales running from "much less than most children" to "much more than most children". Do not mark the midpoint on any of the scales. Even though it may sometimes be difficult to make a judgment, please make a rating on one or the other side of the scale.

1. Hyperactivity - Involuntary and constant overactivity; advanced motor development (throwing things, walking, running, etc.); always on the move; rather run than walk; rarely sits still; always getting into something.

much less than most children	less	slightly less	slightly more	more	much more than most children

2. Short Attention Span and Poor Powers of Concentration - Concentration on a single activity is usually short, with frequent shifting from one activity to another; rarely sticks to a single task very long.

much less than most children	less	slightly less	slightly more	more	much more than most children

3. Variability - Behavior is unpredictable, with wide fluctuations in performance; "sometimes he (or she) is good and sometimes bad".

much less than most children	less	slightly less	slightly more	more	much more than most children

4. Impulsiveness and Inability to Delay Gratification - Does things on the spur of the moment without thinking; seems unable to tolerate any delay in gratification of his (her) needs and demands; when wants anything, he (she) wants it immediately; does not look ahead or work toward future goals; thinks only of immediate present situation.

much less than most children	less	slightly less	slightly more	more	much more than most children

5. Irritability - Frustration tolerance is low; frequently in an ugly mood, often unprovoked; easily upset if everything does not work out just the way he (she) desires.

much less than most children	less	slightly less	slightly more	more	much more than most children

6. Explosiveness - Fits of anger are easily provoked; reactions are often almost volcanic in their intensity; shows explosive, temper-tantrum type of emotional outbursts.

much less than most children	less	slightly less	slightly more	more	much more than most children

APPENDIX B

Factor Scores for 119 Learning Disabled Children

Subject	Score	Subject	Score	Subject	Score
1	0.490	41	0.744	81	0.448
2	-0.817	42	-0.314	82	0.177
3	0.961	43	0.428	83	1.905
4	0.725	44	-0.677	84	1.160
5	-0.606	45	-0.248	85	0.339
6	0.332	46	0.028	86	-0.570
7	0.290	47	0.867	87	-0.852
8	-0.248	48	1.195	88	0.085
9	-0.633	49	-0.219	89	-1.566
10	0.481	50	0.658	90	0.921
11	0.339	51	-0.428	91	-1.013
12	1.126	52	0.367	92	-1.109
13	-2.244	53	1.624	93	0.076
14	-1.932	54	-0.855	94	-0.344
15	-0.262	55	0.381	95	1.335
16	-1.093	56	0.568	96	1.170
17	-1.494	57	1.625	97	0.137
18	-0.440	58	0.436	98	-1.552
19	1.367	59	1.634	99	1.060
20	1.186	60	-0.428	100	0.534
21	0.064	61	0.336	101	0.436
22	-0.841	62	-1.175	102	-0.053
23	-1.389	63	-0.234	103	0.535
24	0.563	64	0.719	104	1.905
25	0.590	65	0.759	105	-1.552
26	0.092	66	0.304	106	-2.416
27	0.043	67	1.397	107	-1.964
28	0.763	68	0.177	108	1.209
29	-0.072	69	-1.123	109	-1.693
30	-0.570	70	-0.805	110	-1.552
31	0.177	71	0.461	111	0.228
32	-0.687	72	-0.779	112	-0.775
33	-0.687	73	-1.055	113	-1.552
34	0.318	74	1.486	114	0.948
35	0.023	75	0.804	115	-1.552
36	0.162	76	1.905	116	1.477
37	0.099	77	-1.115	117	0.337
38	1.153	78	-1.961	118	-1.552
39	1.412	79	0.177	119	-1.552
40	0.184	80	0.177		

APPENDIX C

May 12, 1975

Dear Parent/Guardian:

The Department of Educational Psychology are deeply interested in the learning problems of children. As a part of this continuing interest I am planning to study the way children learn in a controlled environment. I have selected a group of children from several schools in the city, and your child is one of these in the group. Probably there are 5 other children from his school who have been included, who will be given the same tests that your child will take. The tests, which are harmless, have to be done in a soundproof laboratory located on the 6th floor of the New Education Building at the University of Alberta. The testing will give us information about the child's ability to concentrate on the task and the manner in which he approaches a task. The testing will take half a day for a group of 3 children. The School Board has approved this study.

As a result of these tests we will know more about how children learn. The findings of the tests will also help the teacher and parent understand how children learn. I am going to prepare a popular article on understanding children's learning after completing this study. This article will be available for distribution to all parents and teachers who may be interested.

I will drive your child from his school to the University and bring him back (I have taken insurance coverage for doing so). Thus I will assume full supervision of the transportation and supervision of your child while at the University.

It will be greatly appreciated if you can fill in the consent form and have your child give it to the teacher by Friday, May 16. If you would like to ask any questions about the tests, please phone me between 6:00 p.m. and 9:00 p.m. at 436-2697. If this is inconvenient, call 432-5840 during the day, leave a message, and I will return your call. Thank you.

Yours sincerely,

____
DATE

I, _______________________, of _______________________
NAME ADDRESS

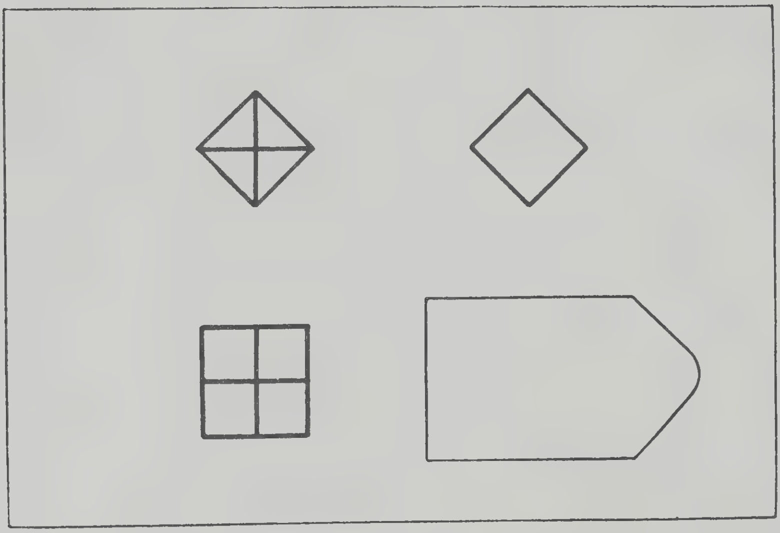
as parent (guardian) of _______________________, do hereby give
CHILD

permission for his/her participation in a University of Alberta Educational Psychology research project to be conducted by Noel Williams, Department of Educational Psychology, Faculty of Education.

Signed _______________________________

APPENDIX D

Sample Item from Raven's Progressive Matrices



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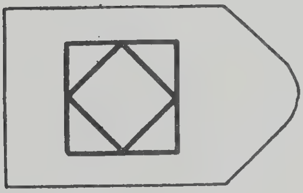

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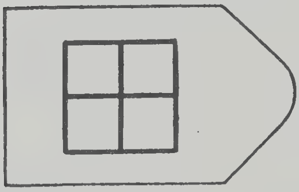

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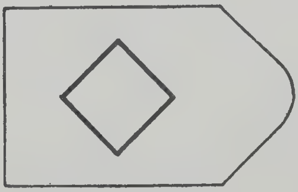

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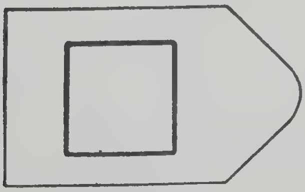
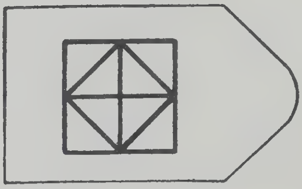
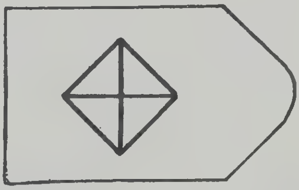


5



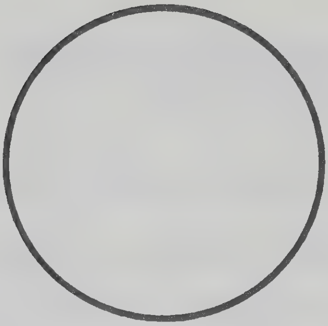
6



APPENDIX E

Figure Copying Test

1.



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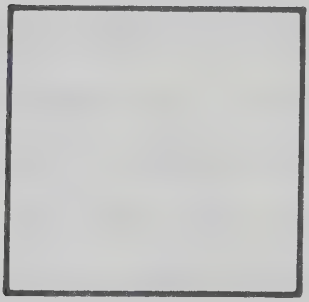

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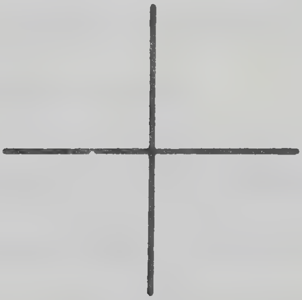
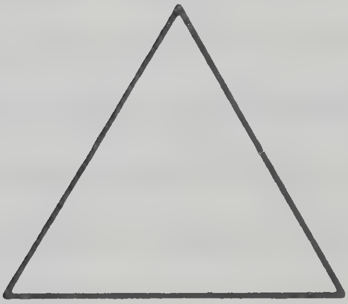
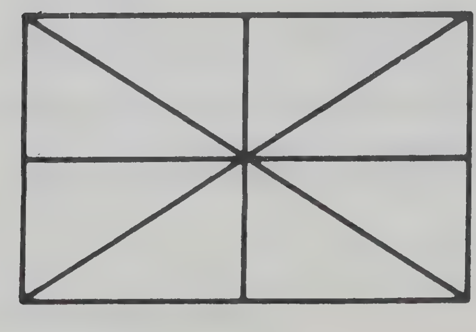


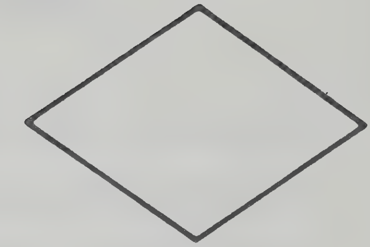
4.



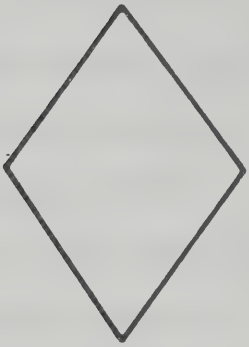
5.



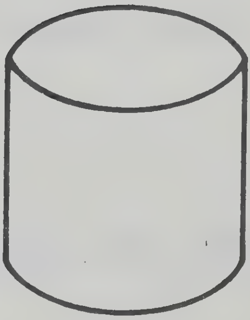
6.



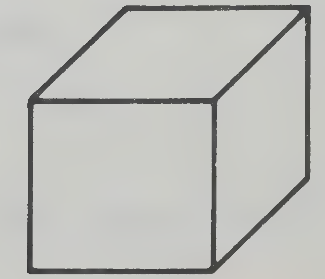
7.



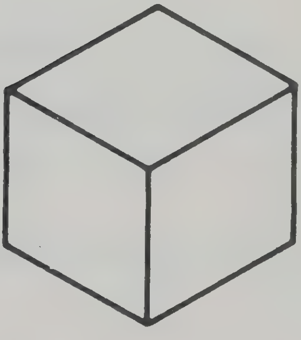
8.



9.



10.



Guidelines for Administering and Scoring the Figure Copying Test[1]

The child is asked to make an exact, free-hand copy of ten shapes: a circle, a square, a cross, a triangle, a rectangle with intersecting diagonals and midlines, a diamond in which length is 1.7 times height, a diamond in which height is 1.7 times length, a cylinder and two cuboids in different perspectives. No time limit is given. Each drawing is scored as 0, 1 or 2 according to the degree of correctness of the production. The total score is the sum of the scores for the individual drawings with a range from 0 to 20. The scoring criterion is one of exactitude of shape and not the absolute size of the drawing. These scoring principles apply:

General principles for all drawings

1. The drawing must have the correct general shape and look like that which it is supposed to be.
2. The drawing should be approximately symmetrical.
3. Angles should not be rounded.
4. The drawing should not be rotated
5. Angles must be approximately opposite each other (except for the triangle).
6. Slight bowing or irregularity of lines is allowed.
7. Lines should meet approximately, but as long as other criteria are met small gaps at junctions are acceptable.

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[1] From Leong (1974).

8. Slight crossing and overlapping of lines is permitted.
9. If two attempts are made in a single drawing score for the worst one.
10. Provided other criteria are met, neatness is not important.

Scoring principles specific to each drawing

1. Circle
   - (a) No diameter of the circle may be as much as 1 1/2 times as long as any other.
   - (b) The drawing must not be angled.
   - (c) Overlapping of curved lines is permitted.
2. Square
   - (a) The angle must be approximately 90^o.
   - (b) The drawing must be symmetrical.
   - (c) No side may be as much as 1 1/2 times the length of any other side.
3. Cross
   - (a) The drawing must be approximately 90^o.
   - (b) No side may be as much as 1 1/2 times the length of any other side.
4. Triangle
   - (a) No side may be as much as 1 1/2 times as long as any other side.
   - (b) There must be three well-defined angles.

5. Rectangle with intersecting diagonals and midlines

   (a) The drawing must be rectangular with angles approximately 90°.

   (b) The diagonals must run from one corner to the opposite one.

   (c) The midlines, both horizontal and vertical, must run approximately in the middle of the drawing.

   (d) The diagonals and midlines should intersect one another at approximately the "midpoint" of the drawing.

6, 7. Diamonds

   (a) There must be four well-defined angles.

   (b) The drawing must be more diamond-shaped than square or kite-shaped.

   (c) The pairs of angles must be approximately opposite.

   (d) For drawing no. 6, the length of the diamond should be approximately from 1 1/2 to 2 times the height. For drawing no. 7 this is reversed.

8. Cylinder

   (a) The diameters of the base and the top should be approximately equal and these in turn should be approximately the same as the height.

   (b) The base and the top lines should be curved.

9, 10. Cuboids in different perspectives

   (a) Proper perspective must be preserved as in the specimens.

   (b) Lengths, widths and heights should be approximately equal.

APPENDIX F

Serial and Free Recall Tests

Examples: A. big long great tall
B. cow day key few
C. man mad map pan

key hot cow pen
wide large big high
day cow wall bar
long big fat great
pen wall book key
book bar wall hot
key few hot book
high fat huge wide
huge great fat large
key day cow bar
wide tall large huge
bar pen few day

40 second rest

wide long big great
great high tall long
few pen hot wall
day cow bar wall
tall fat large high
long big great fat
few day cow book
tall long big huge
key book day hot
wide huge long large
high tall fat big
pen few wall cow

APPENDIX G

Digit Span

Series	Trial 1	Trial 2
3	3 - 8 - 6	6 - 1 - 2
4	3 - 4 - 1 - 7	6 - 1 - 5 - 8
5	8 - 4 - 2 - 3 - 9	5 - 2 - 1 - 8 - 6
6	3 - 8 - 9 - 1 - 7 - 4	7 - 9 - 6 - 4 - 8 - 3
7	5 - 1 - 7 - 4 - 2 - 3 - 8	9 - 8 - 5 - 2 - 1 - 6 - 3
8	1 - 6 - 4 - 5 - 9 - 7 - 6 - 3	2 - 9 - 7 - 6 - 3 - 1 - 5 - 4
9	5 - 3 - 8 - 7 - 1 - 2 - 4 - 6 - 9	4 - 2 - 6 - 9 - 1 - 7 - 8 - 3 - 5

APPENDIX H

Color Naming

RED	BLUE	YELLOW	BLUE	GREEN
RED	GREEN	RED	YELLOW	BLUE
BLUE	GREEN	YELLOW	RED	YELLOW
GREEN	YELLOW	RED	GREEN	BLUE
RED	GREEN	BLUE	YELLOW	GREEN
YELLOW	BLUE	RED	BLUE	GREEN
BLUE	GREEN	YELLOW	RED	YELLOW
BLUE	RED	YELLOW	GREEN	RED

APPENDIX I

Table I-1

ANOVA and Scheffé Test for Three PA Groups and Control Group on Seven GSR Variables

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Latency 1

ANOVA

Source	SS	MS	DF	F	P
Groups	152.78516	50.93	3	4.63	0.005320
Error	725.5703	10.99	66		

Probability matrix for Scheffé multiple comparison of means

	1	2	3	4
1. POA	1.0000	1.0000	0.0211	0.9102
2. PNA	1.0000	1.0000	0.0235	0.9235
3. PUA	0.0211	0.0235	1.0000	0.0946
4. Control	0.9102	0.9235	0.0946	1.0000

Latency 2

ANOVA

Source	SS	MS	DF	F	P
Groups	3221.4023	1073.80	3	13.11	0.000002
Error	5407.6602	81.93	66		

Probability matrix for Scheffé multiple comparison of means

	1	2	3	4
1. POA	1.0000	0.0967	0.0000	0.1713
2. PNA	0.0967	1.0000	0.0075	0.9874
3. PUA	0.0000	0.0075	1.0000	0.0019
4. Control	0.1713	0.9874	0.0019	1.0000

Table I-1 (continued)

ANOVA and Scheffé Test for Three PA Groups and Control Group on Seven GSR Variables

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Magnitude

ANOVA

Source	SS	MS	DF	F	P
Groups	19.211487	6.40	3	8.97	0.000046
Error	47.101868	0.71	66		

Probability matrix for Scheffé multiple comparison of means

	1	2	3	4
1. POA	1.0000	0.0016	0.0003	0.0040
2. PNA	0.0016	1.0000	0.9652	0.9828
3. PUA	0.0003	0.9652	1.0000	0.8287
4. Control	0.0040	0.9828	0.8287	1.0000

Recovery limb

ANOVA

Source	SS	MS	DF	F	P
Groups	67477.813	22492.60	3	15.58	0.000001
Error	95267.375	1443.45	66		

Probability matrix for Scheffé multiple comparison of means

	1	2	3	4
1. POA	1.0000	0.0353	0.0000	0.1619
2. PNA	0.0353	1.0000	0.0060	0.8880
3. PUA	0.0000	0.0060	1.0000	0.0004
4. Control	0.1619	0.8880	0.0004	1.0000

Table I-1 (continued)

ANOVA and Scheffé Test for Three PA Groups and Control Group on Seven GSR Variables

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Spontaneous fluctuations

ANOVA

Source	SS	MS	DF	F	P
Groups	729.74609	243.25	3	2.04	0.116972
Error	7875.4570	119.33	66		

Probability matrix for Scheffé multiple comparison of means

	1	2	3	4
1. POA	1.0000	0.9995	0.4261	0.9429
2. PNA	0.9995	1.0000	0.3610	0.9704
3. PUA	0.4261	0.3610	1.0000	0.1493
4. Control	0.9429	0.9704	0.1493	1.0000

Habituation rate

ANOVA

Source	SS	MS	DF	F	P
Groups	255.33594	85.11	3	3.97	0.011519
Error	1413.8086	21.42	66		

Probability matrix for Scheffé multiple comparison of means

	1	2	3	4
1. POA	1.0000	0.6847	0.0279	0.9913
2. PNA	0.6847	1.0000	0.3203	0.8320
3. PUA	0.0279	0.3203	1.0000	0.0493
4. Control	0.9913	0.8320	0.0493	1.0000

Table I-1 (continued)

ANOVA and Scheffé Test for Three PA Groups and Control Group on Seven GSR Variables

Basal level

ANOVA

Source	SS	MS	DF	F	P
Groups	26.077393	8.69	3	27.20	0.000001
Error	21.089355	0.32	66		

Probability matrix for Scheffé multiple comparison of means

	1	2	3	4
1. POA	1.0000	0.0000	0.0000	0.0001
2. PNA	0.0000	1.0000	0.1380	0.5662
3. PUA	0.0000	0.1380	1.0000	0.0034
4. Control	0.0001	0.5062	0.0034	1.0000

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